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Offsite Environmental Monitoring Report:

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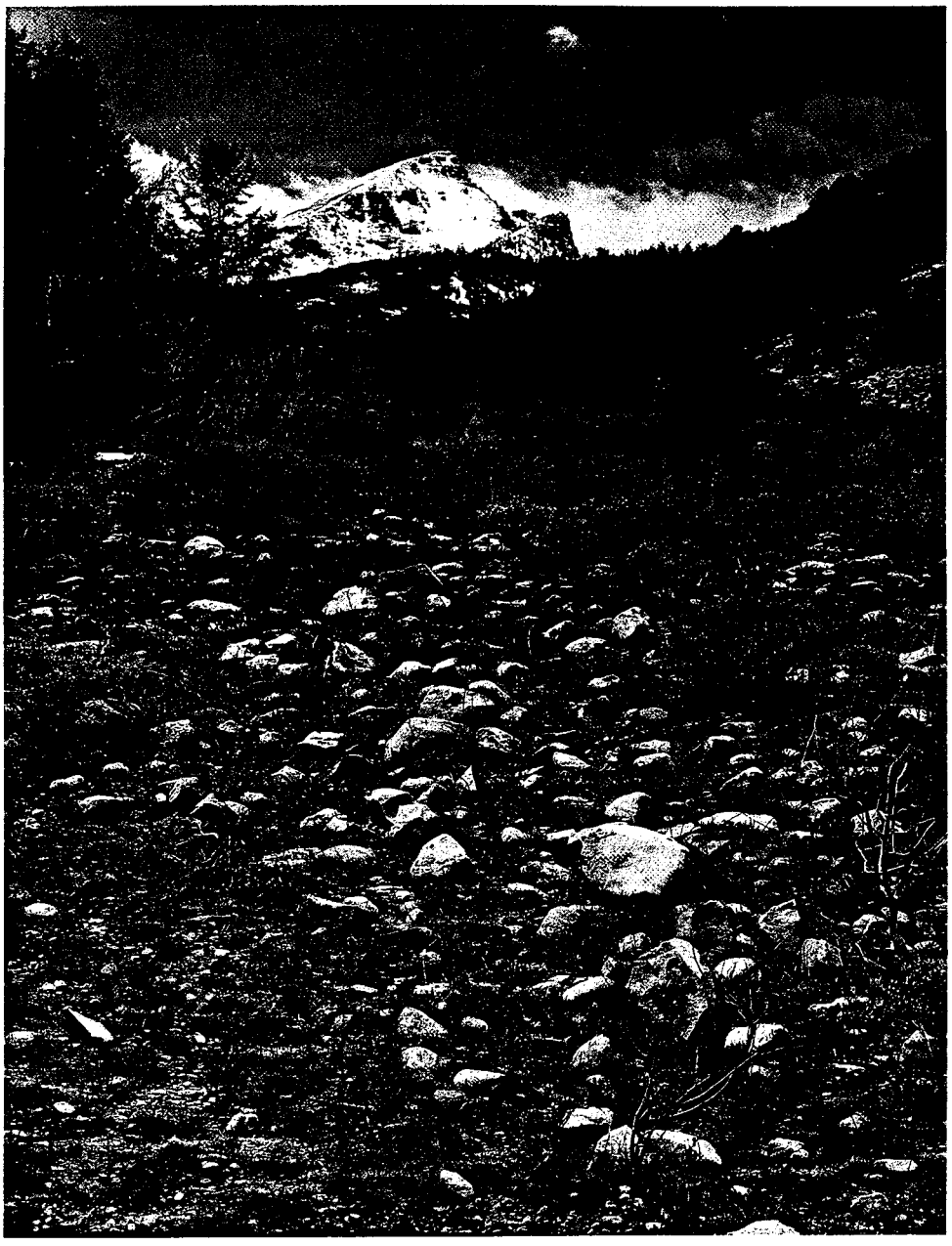
Radiation Monitoring Around United States Nuclear Test Areas Calendar Year 1990



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Offsite Environmental Monitoring Report:

Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1990

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OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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Notice

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Abstract

This report describes the Offsite Radiation Safety Program conducted during 1990 by the Environmental Protection Agency's (EPA's) Environmental Monitoring Systems Laboratory-Las Vegas. This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site (NTS) and at former test sites in Alaska, Colorado, Mississippi, Nevada, and New Mexico. The surveillance program is designed to measure levels and trends of radioactivity, if present, in the environment surrounding testing areas to ascertain whether current radiation levels and associated doses to the general public are in compliance with existing radiation protection standards. The surveillance program additionally has the responsibility to take action to protect the health and well being of the public in the event of any accidental release of radioactive contaminants. Offsite levels of radiation and radioactivity are assessed by sampling milk, water, and air; by deploying thermoluminescent dosimeters (TLDs) and using pressurized ion chambers (PICs); and by biological monitoring of animals, food crops, and humans. Personnel with mobile monitoring equipment are placed in areas downwind from the test site prior to each nuclear weapons test to implement protective actions, provide immediate radiation monitoring, and obtain environmental samples rapidly after any occurrence of radioactivity release.

Comparison of the measurements and sample analysis results with background levels and with appropriate standards and regulations indicated that there was no radioactivity detected offsite by the various EPA monitoring networks and no exposure above natural background to the population living in the vicinity of the NTS that could be attributed to current NTS activities. Annual and long-term (10-year) trends were evaluated in the Noble Gas and Tritium, Milk Surveillance, Biomonitoring, TLD, PIC networks, and the Long-Term Hydrological Monitoring Program. All evaluated data were consistent with previous data history. No radiation directly attributable to current NTS activities was detected in any samples. Monitoring network data indicate the greatest population exposure came from naturally occurring background radiation, which yielded an average exposure of 123 mrem/yr. Worldwide fallout accounted for about 0.01 mrem/yr. Calculation of potential dose to offsite residents based on onsite source emission measurements provided by the Department of Energy (DOE) resulted in a maximum calculated dose of 0.006 mrem/yr. These were insignificant contributors to total exposure as compared to natural background.

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Tables

Abbreviations, Acronyms, Units of Measure, and Conversions

ABBREVIATIONS and ACRONYMS

ALARA — As Low as Reasonably Achievable
ALI — Annual Limit on Intake
ASN — Air Surveillance Network
ANSI — American National Standards Institute
BLM — Bureau of Land Management
BOMAB — Bottle Mannequin Absorber
CFR — Code of Federal Regulations
CG — Concentration Guide
CMS — Community Monitoring Station
CP-1 — Control Point One
DAC — Derived Air Concentration
DOE — U.S. Department of Energy
DOELAP — Department of Energy, Laboratory Accreditation Program
DQO — data quality objective
DRI — Desert Research Institute
EML — Environmental Monitoring Laboratory
EMSL-LV — Environmental Monitoring Systems Laboratory, Las Vegas
EPA — U.S. Environmental Protection Agency
FDA — Food and Drug Administration
Ge(Li) — lithium-drifted germanium diode
GOES — Geostationary Operational Environmental Satellite
HTO — tritiated water
ICRP — International Commission on Radiological Protection
IG — intrinsic germanium
LCL — lower control limit
LTHMP — Long-Term Hydrological Monitoring Program
LWL — lower working limit
MDC — minimum detectable concentration
MSL — mean sea level
MSN — Milk Surveillance Network
NCRP — National Council of Radiation Protection and Measurement
NIST — National Institute of Standards and Technology
NGTSN — Noble Gas and Tritium Surveillance Network
NTS — Nevada Test Site
ORSP — Offsite Radiological Safety Program
PIC — pressurized ion chamber
QA — quality assurance
QAMS — Quality Assurance Management Staff
QC — quality control
RAWS — Remote Automatic Weather Station
RCF — reference correction factor
SAIC — Science Applications International Corporation
S.D. — standard deviation
SMSN — Standby Milk Surveillance Network
SOP — standard operating procedure
STDMS — sample tracking data management system
TLD — thermoluminescent dosimeter
UCL — upper control limit
USGS — U.S. Geological Survey
UWL — upper working limit
vs. — versus

Abbreviations, Acronyms, Units of Measure, and Conversions (continued)

UNITS OF MEASURE

Bq	—	Becquerel, one disintegration per second
C	—	coulomb
°C	—	degrees centigrade
Ci	—	Curie
cm	—	centimeter, 1/100 meter
eV	—	electron volt
°F	—	degrees Fahrenheit
g	—	gram
hr	—	hour
keV	—	one thousand electron volts
kg	—	kilogram, 1000 grams
km	—	kilometer, 1000 meters
L	—	liter
lb	—	pound
m	—	meter
meV	—	one million electron volts
mg	—	milligram, 1/1000 gram
min	—	minute
mL	—	milliliter, 1/1000 liter
mo	—	month
mR	—	milliroentgen, 1/1000 roentgen
mrem	—	millirem, 1/1000 rem
mSv	—	millisievert, 1/1000 sievert
pCi	—	picocurie, 1/1,000,000,000,000 curie
qt	—	quarter
R	—	roentgen
rad	—	unit of absorbed dose, 100 ergs/g
rem	—	dose equivalent, the rad adjusted for biological effect
Sv	—	sievert, equivalent to 100 rem
wk	—	week
yr	—	year
µCi	—	microcurie, 1/1,000,000 curie
µR	—	microroentgen, 1/1,000,000 roentgen
%	—	percent
±	—	plus or minus
<	—	less than
=	—	equals
≅	—	approximately equals

PREFIXES

a	atto	=	10^{-18}
f	femto	=	10^{-15}
p	pico	=	10^{-12}
n	nano	=	10^{-9}
µ	micro	=	10^{-6}
m	milli	=	10^{-3}
k	kilo	=	10^{3}

CONVERSIONS

Multiply	by	To Obtain
Concentrations		
µCi/mL	10^{9}	pCi/L
µCi/mL	10^{12}	pCi/m³
SI Units		
rad	10^{-2}	Gray (Gy = 1 Joule/kg)
rem	10^{-2}	Sievert (Sv)
pCi	3.7×10^{-2}	Becquerel (Bq)
mR/yr	2.6×10^{-7}	Coulomb (C)/kg-yr

List of Elements

ATOMIC NUMBER	SYMBOL	NAME
1	H	hydrogen
2	He	helium
3	Li	lithium
4	Be	beryllium
5	B	boron
6	C	carbon
7	N	nitrogen
8	O	oxygen
9	F	fluorine
10	Ne	neon
11	Na	sodium
12	Mg	magnesium
13	Al	aluminum
14	Si	silicon
15	P	phosphorus
16	S	sulfur
17	Cl	chlorine
18	Ar	argon
19	K	potassium
20	Ca	calcium
21	Sc	scandium
22	Ti	titanium
23	V	vanadium
24	Cr	chromium
25	Mn	manganese
26	Fe	iron
27	Co	cobalt
28	Ni	nickel
29	Cu	copper
30	Zn	zinc
31	Ga	gallium
32	Ge	germanium
33	As	arsenic
34	Se	selenium
35	Br	bromine
36	Kr	krypton
37	Rb	rubidium
38	Sr	strontium
39	Y	yttrium
40	Zr	zirconium
41	Nb	niobium
42	Mo	molybdenum
43	Tc	technetium
44	Ru	ruthenium
45	Rh	rhodium
46	Pd	palladium
47	Ag	silver
48	Cd	cadmium
49	In	indium
50	Sn	tin
51	Sb	antimony
52	Te	tellurium
53	I	iodine
54	Xe	xenon
55	Cs	cesium
56	Ba	barium
57	La	lanthanum
58	Ce	cerium
59	Pr	praseodymium
60	Nd	neodymium
61	Pm	promethium
62	Sm	samarium
63	Eu	europium
64	Gd	gadolinium
65	Tb	terbium
66	Dy	dysprosium
67	Ho	holmium
68	Er	erbium
69	Tm	thulium
70	Yb	ytterbium
71	Lu	lutetium
72	Hf	hafnium
73	Ta	tantalum
74	W	tungsten
75	Re	rhenium
76	Os	osmium
77	Ir	iridium
78	Pt	platinum
79	Au	gold
80	Hg	mercury
81	Tl	thallium
82	Pb	lead
83	Bi	bismuth
84	Po	polonium
85	At	astatine
86	Rn	radon
87	Fr	francium
88	Ra	radium
89	Ac	actinium
90	Th	thorium
91	Pa	protactinium
92	U	uranium

List of Elements (continued)

ATOMIC NUMBER	SYMBOL	NAME
93	Np	neptunium
94	Pu	plutonium
95	Am	americium
96	Cm	curium
97	Bk	berkelium
98	Cf	californium
99	Es	einsteinium
100	Fm	fermium
101	Md	mendelevium
102	No	nobelium
103	Lr	lawrencium

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1 Introduction

C. A. Fontana

The U.S. Atomic Energy Commission used the Nevada Test Site (NTS), between January 1951 and January 1975, for conducting nuclear weapons tests, nuclear rocket engine development, nuclear medicine studies, and for other nuclear and nonnuclear experiments. Beginning in mid-January 1975, these activities became the responsibility of the U.S. Energy Research and Development Administration. Two years later this organization was merged with other energy-related agencies to form the U.S. Department of Energy (DOE).

Atmospheric weapons tests were conducted periodically at the NTS from January 1951 through October 1958, followed by a test moratorium which was in effect until September 1961. Since then all nuclear detonations at the NTS have been conducted underground, with the expectation of containment, except for the above ground and shallow underground tests of Operation Sunbeam and in cratering experiments conducted under the Plowshare program between 1962 and 1968.

Prior to 1954, an offsite radiation surveillance program was performed by personnel from the Los Alamos Scientific Laboratory and the U.S. Army. Beginning in 1954 and continuing through 1970, this program was conducted by the U.S. Public Health Service. Since 1970, the U.S. Environmental Protection Agency (EPA) has operated the Offsite Radiological Safety Program (ORSP), both in Nevada and at other nuclear test sites, under interagency agreements with the DOE or its predecessor agencies.

Since 1954, the three major objectives of the offsite radiation surveillance program have been:

- Measuring and documenting levels and trends of environmental radiation or radioactive contaminants in the vicinity of atomic testing areas.
- Verifying compliance with applicable radiation protection standards, guidelines, and regulations.
- Assuring the health and safety of the people living in the vicinity of the NTS.

Offsite levels of radiation and radioactivity are assessed by gamma-ray measurements using pressurized ion chambers and thermoluminescent dosimeters; by sampling air, water, milk, food crops, other vegetation, soil, animals; and humans using biological assay procedures.

Before each nuclear test at the NTS, EPA radiation monitoring technicians are stationed in offsite areas most likely to be affected by an airborne release of radioactive material. These technicians use trucks equipped with radiation detectors, samplers, and supplies and are directed by two-way radio from the control center at the NTS.

Hours before each test, Weather Service Nuclear Support Office personnel and, if requested, an instrumented aircraft gather meteorological data for use by the Test Controller's Advisory Panel in judging the safety of executing the test. A second aircraft carries radiation detectors. In the unlikely event of a significant release of radioactivity following a nuclear weapons test, the equipment on the aircraft enables rapid sampling and analysis of a radioactive cloud. Data gathered by the aircraft are used to assist in deploying field monitoring technicians to downwind areas, to help determine appropriate protective actions, and to perform radiation monitoring and environmental sampling (EPA88B).

Beginning with operation Upshot-Knothole in 1953, a report summarizing the monitoring data obtained from each test series was published by the U.S. Public Health Service. For the reactor tests in 1959 and the weapons and Plowshare tests in 1962, data were published only for the tests in which detectable amounts of radioactivity were measured in an offsite area. Publication of the summary data for each six-month period was initiated in 1964. In 1971, the Atomic Energy Commission implemented a requirement (AEC71), subsequently incorporated into Department of Energy Order 5484.1 (DOE85), that

each agency or contractor involved in major nuclear activities provide an annual comprehensive radiological monitoring report. During 1988, Order 5484.1 was superseded by the General Environmental Protection Program Requirements (Order 5400.1) (DOE88) of the DOE. Each annual report summarizes the radiation monitoring activities of the EPA in the vicinity of the NTS and at former nuclear testing areas in the United States. This report summarizes those activities for calendar year 1990.

Included in this report are descriptions of the pertinent features of the NTS and its environs; summaries of the dosimetry and sampling methods; a delineation of analytical and quality control procedures; and the results of environmental measurements. Where applicable, dosimetry and analytical data are compared with appropriate standards and guidelines for the external and internal exposure of humans to ionizing radiation.

Although written to meet the terms of the interagency agreement between the EPA and the DOE as well as the requirements of DOE Order 5400.1, the data and information contained in this report should also be of interest and use to the citizens of Nevada, Utah and California. State, federal, and local agencies involved in protecting the environment and the health and well-being of the public, and individuals and organizations concerned with environmental quality and the possible release of radioactive contaminants into the biosphere, may also find the contents of this report of interest.

2 Summary

C. A. Fontana and D. J. Chaloud

The primary functions of the ORSP are to conduct routine environmental monitoring for radioactive materials in areas potentially impacted by nuclear tests and, when necessary, to implement actions to protect the public from radiation exposure. Components of the ORSP include surveillance networks for air, noble gas and tritium, and milk; biomonitoring of meat, game animals, and vegetables; exposure monitoring by thermoluminescent dosimetry, pressurized ion chambers, and whole body counting; and long-term hydrological monitoring of wells and surface waters. In 1990, data from all networks and monitoring programs indicated no radiation directly attributable to current activities conducted at DOE's NTS and there was no need for any protective actions to be undertaken. The highest calculated (modeled) dose was 6 x 10^{-3} mrem (6 x 10^{-5} mSv) to hypothetical populations living within 48 miles (80 km) of Control Point One (CP-1).

2.1 OBJECTIVE

"EPA is charged by Congress to protect the nation's air and water systems" (EPA89). This policy applies to exposure of the population to radiation and radioactive contaminants. To accomplish these goals and to ensure compliance with the DOE policy of keeping radiation exposure of the general public as low as reasonably achievable (ALARA), the EPA's Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) conducts the ORSP around the DOE's NTS. This program is conducted under an Interagency Agreement between EPA and DOE. The main activity at the NTS is the testing of nuclear devices; however, other related projects are also conducted.

The principal activities of the ORSP are to: (1) conduct routine environmental monitoring for radioactive materials in various media and for radiation in areas that may be affected by nuclear tests; (2) implement protective actions in support of the nuclear testing program; and, (3) gather information to direct protective actions, where needed. These activities are conducted to document compliance with standards, to identify trends, and to provide information to the public. This report summarizes these activities for the calendar year 1990.

2.2 AIR SURVEILLANCE NETWORK

In 1990, the Air Surveillance Network (ASN) consisted of 32 continuously operating sampling locations surrounding the NTS and 78 standby stations, operated one or two weeks each quarter. In 1990, sampling was conducted at 75 of the 78 standby stations. At least one sampler is located in each state west of the Mississippi River. No airborne radioactivity related to current nuclear testing at the NTS was detected in any sample from the ASN during 1990. Apart from naturally occurring ^{7}Be, the only activity above the minimum detectable concentration (MDC) detected by this network was ^{238}Pu in two composite samples from Rachel and Las Vegas, NV, and $^{239+240}$Pu in one composite sample from Austin and Amarillo, TX. Operation of the ASN and data results are discussed in Section 4.2.2.

2.3 NOBLE GAS AND TRITIUM SURVEILLANCE NETWORK

The Noble Gas and Tritium Surveillance Network (NGTSN) consisted of 16 noble gas and 19 tritium sampling stations in 1990. No NTS-related activity was detected at any network sampling station. As in previous years, results for xenon and tritium were typically below the MDC. Krypton results, although exceeding the MDC, were within the range of values expected from sampling background levels, as discussed in Section 4.2.3.

2.4 MILK SURVEILLANCE NETWORK

The Milk Surveillance Network consisted of 26 locations within 180 miles (300 km) of the NTS and an additional 109 standby locations in the contiguous states west of the Mississippi River, with the exception of Texas. As discussed in Section 4.2.4, a single sample from Boise, ID contained minimally detectable amounts of ^{3}H and detectable levels of ^{90}Sr were found in samples from two locations (Shoshone, NV

and Ivins, UT). Both the Boise and Ivins samples were within the expected range of false positive values. The Shoshone samples indicated concentrations were above the MDC in three of four samples taken between May and November. Similar results were noted in 1989 during the same seasonal period, coinciding with cattle grazing on green forage.

2.5 BIOMONITORING PROGRAM

Meat, home-grown fruits and vegetables, and game animals are analyzed in the biomonitoring program. In 1990, cattle, desert bighorn sheep, mule deer, and root crop vegetables were analyzed for tritium, strontium, plutonium, and gamma emitters. As discussed in Section 4.2.5, most sample results were less than the MDC. Those samples with concentrations above the MDC were similar to results seen in previous years. Detectable levels of $^{239+240}Pu$ in beets from St. George, UT, were attributed to incomplete washing of soil from the sample prior to processing.

2.6 THERMOLUMINESCENT DOSIMETRY PROGRAM

In 1990, external exposure was monitored by a network of thermoluminescent dosimeters (TLD) at 134 fixed locations surrounding the NTS and by TLDs worn by 71 offsite residents. No apparent net exposures were related to NTS activities. As discussed in Section 4.2.6, regulatory or ALARA investigation limits were not exceeded for any individual or cumulative exposure. The range of exposures was similar to those observed in other areas of the U.S.

2.7 PRESSURIZED ION CHAMBER NETWORK

The pressurized ion chamber (PIC) network measures ambient gamma radiation exposure rates. The 28 PICs deployed around the NTS in 1990 showed no unexplained deviations from background levels. The maximum annual average exposure rate of 160 mR/yr was measured in Austin, NV; the minimum of 50 mR/yr was recorded in Las Vegas, NV. As discussed in Section 4.2.7, these values are within the U.S. background range (BIER80) and are consistent with previous years' trends.

2.8 INTERNAL EXPOSURE MONITORING

Internal exposure is assessed by whole body counting using a single intrinsic coaxial germanium detector, lung counting using six intrinsic germanium semiplanar detectors, and bioassay using radiochemical procedures. In 1990, analyses were made on 236 individuals, 120 of whom were regular participants in the monitoring program. As discussed in Section 4.2.8, tritium concentrations higher than the MDC were measured in four percent of the subjects; however, the highest value was 0.3 percent of the annual limit for uptake. Medical examinations conducted as part of the monitoring program revealed a normally healthy population consistent with the age and sex distribution of that population.

2.9 LONG-TERM HYDROLOGICAL MONITORING PROGRAM

In 1990, the Long-Term Hydrological Monitoring Program (LTHMP), discussed in Section 4.2.9, analyzed samples taken from 265 wells, springs, and other sources near locations of underground nuclear explosive tests. Only background radionuclide concentrations were measured, with the exception of tritium concentrations in samples from sources known to be affected by underground nuclear testing or those spiked with radionuclides for hydrological tests. In all cases, the wells displaying elevated tritium concentrations are not part of the public drinking water supply.

2.10 QUALITY ASSURANCE PROGRAM

The quality assurance (QA) program for the ORSP is in full compliance with EPA mandates for data-generating monitoring programs. As detailed in Chapter 6, the QA program includes development of and adherence to standard operating procedures (SOP), monitoring of data quality objectives (DQO), standardized data validation procedures, health physics oversight, and participation in the EPA QA Intercomparison Study Program. In 1990, DQOs were met for precision and accuracy for all components of the ORSP.

2.11 COMMUNITY MONITORING STATIONS

The Community Monitoring Stations (CMS) are integral parts of the ASN, NGTSN, TLD, and PIC networks. These community stations are operated

by local residents for the EPA, DOE, and Desert Research Institute (DRI). Nineteen stations have been fully operational since 1988. All data measurements from CMSs in 1990 were within the normal background range for the U.S. Results from CMS samples are included in this report as part of the networks in which they participate.

2.12 DOSE ASSESSMENT

Dose assessments for 1990 were calculated using an atmospheric dispersion model (AIRDOS/EPA) and NTS-reported releases. Dose assessments could not be made on the basis of measured results because no radioactivity related to current NTS operations was observed in the monitoring network results in 1990. The highest individual dose calculated using the model was approximately 6×10^{-3} mrem to a hypothetical person residing in Crystal, NV, a small residential community north of Pahrump, NV. Compared to natural background, NTS activities and worldwide fallout contributed a negligible amount of the calculated exposure. Chapter 7 describes the procedures used to calculate the dose assessment for 1990.

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3 Description of the Nevada Test Site

C. A. Fontana

The principal activity at the NTS is the testing of nuclear devices to aid in the development of nuclear weapons, proof testing of weapons, and weapons safety and effects studies. The major activity of the EPA's ORSP is radiation monitoring around the NTS. This section provides an overview of the climate, geology and hydrology, and land uses in this generally arid and sparsely populated area of the southwestern United States (Figure 1). The information included should provide an understanding of the environment in which nuclear testing and monitoring activities take place, the reasons for the location of instrumentation, the weather extremes to which both people and equipment are subjected, and the distances traveled by field monitoring technicians in collecting samples and maintaining equipment.

3.1 LOCATION

The NTS is located in Nye County, NV, with its southeast corner about 54 miles (90 km) northwest of Las Vegas (Figure 2). It occupies an area of about 1,350 square miles (3,750 square km), varies from 28 to 35 miles (46 to 58 km) in width (east-west) and from 49 to 55 miles (82 to 92 km) in length (north-south). This area consists of large basins or flats about 2,970 to 3,900 feet (900 to 1,200 m) above mean sea level (MSL) surrounded by mountain ranges rising from 5,940 to 7,590 feet (1,800 to 2,300 m) above MSL.

The NTS is surrounded on three sides by exclusion areas, collectively named the Nellis Air Force Base Range Complex, which provides a buffer zone between the test areas and privately owned lands. This buffer zone varies from 14 to 62 miles (24 to 104 km) between the test area and land that is open to the public. In the unlikely event of a venting, two to more than six hours would elapse, depending on wind speed and direction, before any release of airborne radioactivity would reach private lands.

3.2 CLIMATE

The climate of the NTS and surrounding area is variable, due to its wide range in altitude and its rugged terrain. Most of Nevada has a semi-arid climate characterized as mid-latitude steppe. Throughout the year, there is insufficient water to

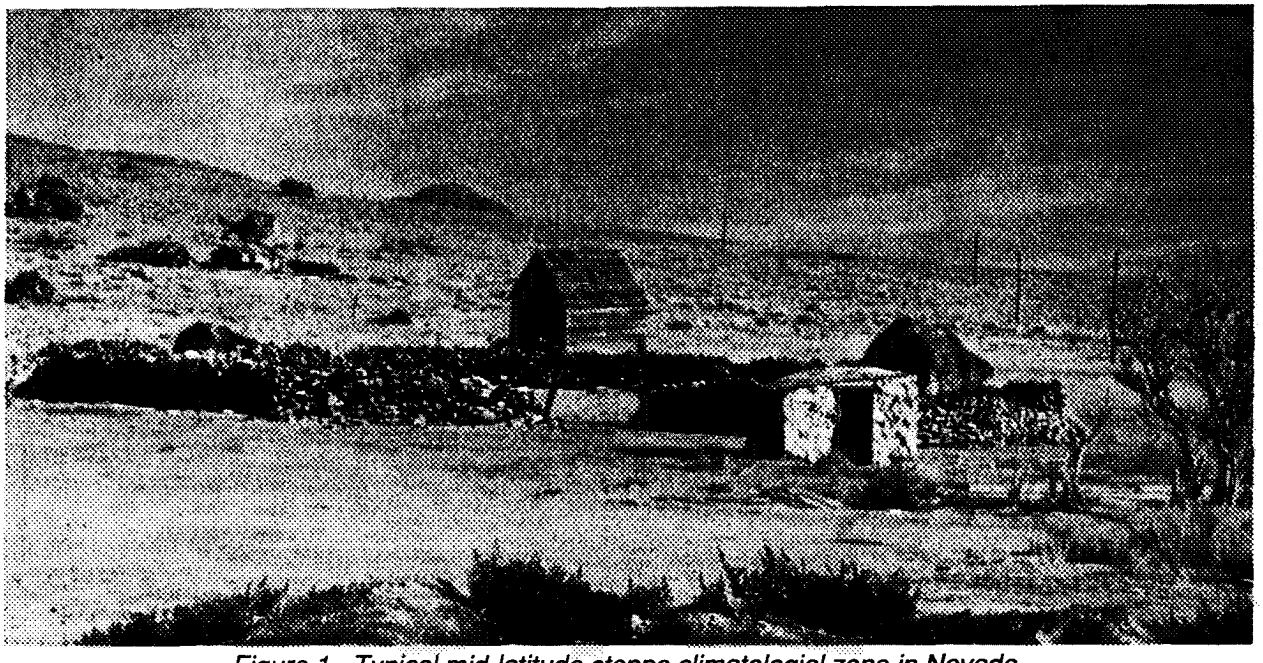

Figure 1. Typical mid-latitude steppe climatologial zone in Nevada.

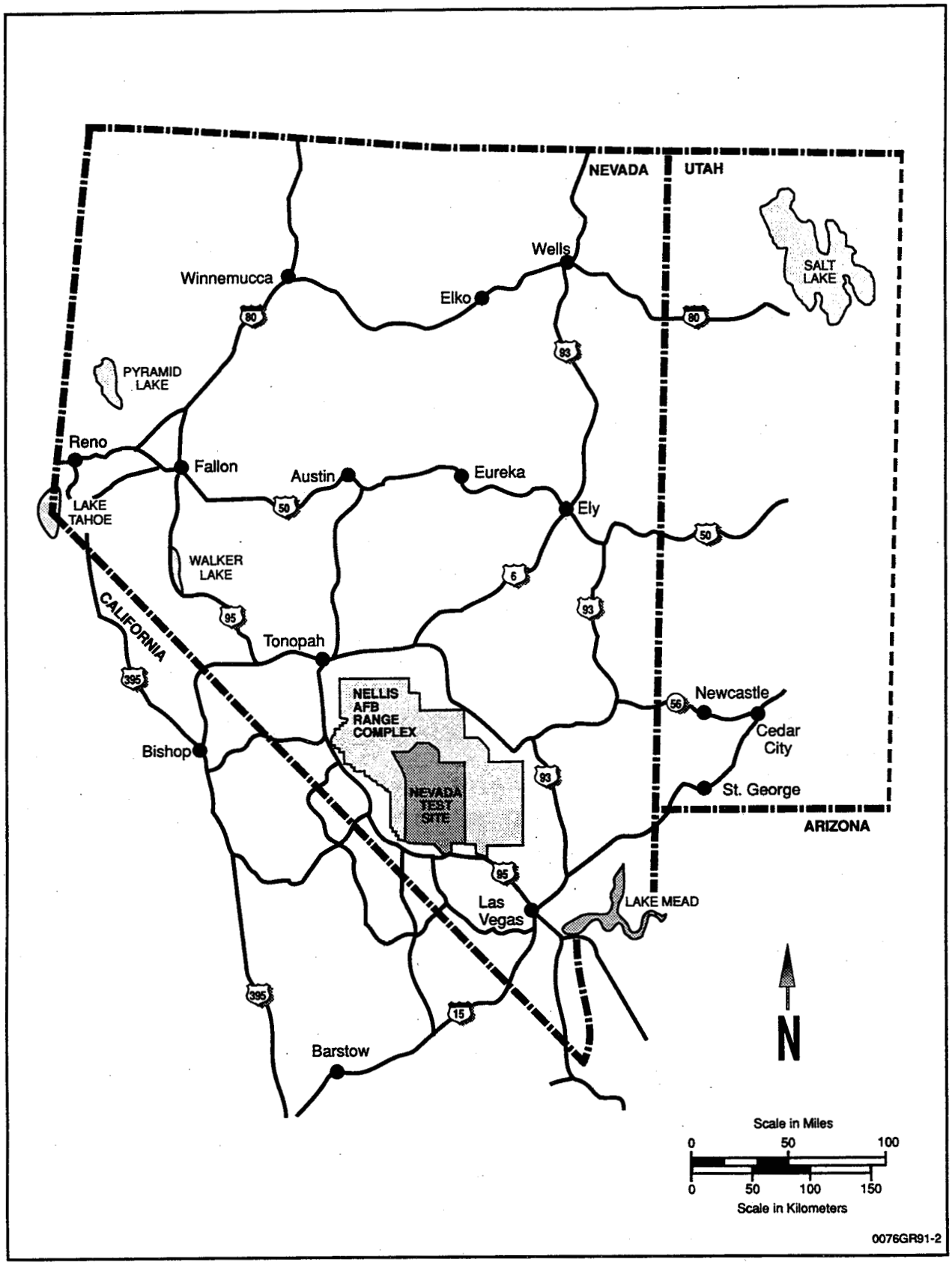

Figure 2. Location of the Nevada Test Site.

support the growth of common food crops without irrigation.

Climate may be classified by the types of vegetation indigenous to an area. According to Houghton et al. (HO75), this method of classification developed by Köppen is further subdivided on the basis of "...seasonal distribution of rainfall and the degree of summer heat or winter cold." Table 1 summarizes the characteristics of climatic types for Nevada.

According to Quiring (QU68), the NTS average annual precipitation ranges from about 4 inches (10 cm) at the lower elevations to around 10 inches (25 cm) on the higher elevations. During the winter months, the plateaus may be snow-covered for a period of several days or weeks. Snow is uncommon on the flats. Temperatures vary considerably with elevation, slope, and local air currents. The average daily temperature ranges at the lower altitudes are around 50 to 25 °F (10 to –4 °C) in January and 95 to 55 °F (35 to 13 °C) in July, with extremes of 120 °F (49 °C) and –15 °F (–26 °C). Corresponding temperatures on the plateaus are 35 to 25 °F (2 to –4 °C) in January and 80 to 65 °F (27 to 18 °C) in July with extremes of 115 °F (46 °C) and –30 °F (–34 °C).

The wind direction, as measured on a 30 m tower at an observation station about 5.4 miles (9 km) northwest of Yucca Lake, is predominantly northerly except during the months of May through August when winds from the south-southwest predominate (QU68). Because of the prevalent mountain/valley winds in the basins, south to southwest winds predominate during daylight hours of most months. During the winter months, southerly winds predominate slightly over northerly winds for a few hours during the warmest part of the day. These wind patterns may be quite different at other locations on the NTS because of local terrain effects and differences in elevation.

3.3 GEOLOGY AND HYDROLOGY

Two major hydrologic systems shown in Figure 3 exist on the NTS (ERDA77). Ground water in the northwestern part of the NTS or in the Pahute Mesa area flows at a rate of 6.6 to 600 feet (2 to 180 m) per year to the south and southwest toward the Ash Meadows discharge area in the Amargosa Desert. Ground water to the east of the NTS moves from north to south at a rate of not less than 6.6 feet (2 m) nor greater than 730 feet (220 m) per year. Carbon-14 analyses of this eastern ground water indicate that the lower velocity is nearer the true value. At Mercury Valley in the extreme southern part of the NTS, the eastern ground water flow shifts to the southwest, toward the Ash Meadows discharge area.

TABLE 1. CHARACTERISTICS OF CLIMATIC TYPES IN NEVADA (from Houghton et al. 1975)

CLIMATE TYPE	MEAN ANNUAL TEMPERATURE °F (°C) WINTER	SUMMER	PRECIPITATION inches (cm) TOTAL*	SNOWFALL	DOMINANT VEGETATION	PERCENT OF AREA
Alpine tundra	0 to 15 (–18 to –9)	40 to 50 (4 to 10)	15 to 45 (38 to 114)	Medium to heavy	Alpine meadows	—
Humid continental	10 to 30 (–12 to –1)	50 to 70 (10 to 21)	25 to 45 (64 to 114)	Heavy	Pine-fir forest	1
Subhumid continental	10 to 30 (–12 to –1)	50 to 70 (10 to 21)	12 to 25 (30 to 64)	Moderate	Pine or scrub woodland	15
Mid-latitude steppe	20 to 40 (–7 to 4)	65 to 80 (18 to 27)	16 to 15 (15 to 38)	Light to moderate	Sagebrush, grass, scrub	57
Mid-latitude desert	20 to 40 (–7 to 4)	65 to 80 (18 to 27)	3 to 8 (8 to 20)	Light	Greasewood, shadscale	20
Low-latitude desert	40 to 50 (–4 to 10)	80 to 90 (27 to 32)	2 to 10 (5 to 25)	Negligible	Creosote bush	7

* *Limits of annual precipitation overlap because of variations in temperature which affect the water balance.*

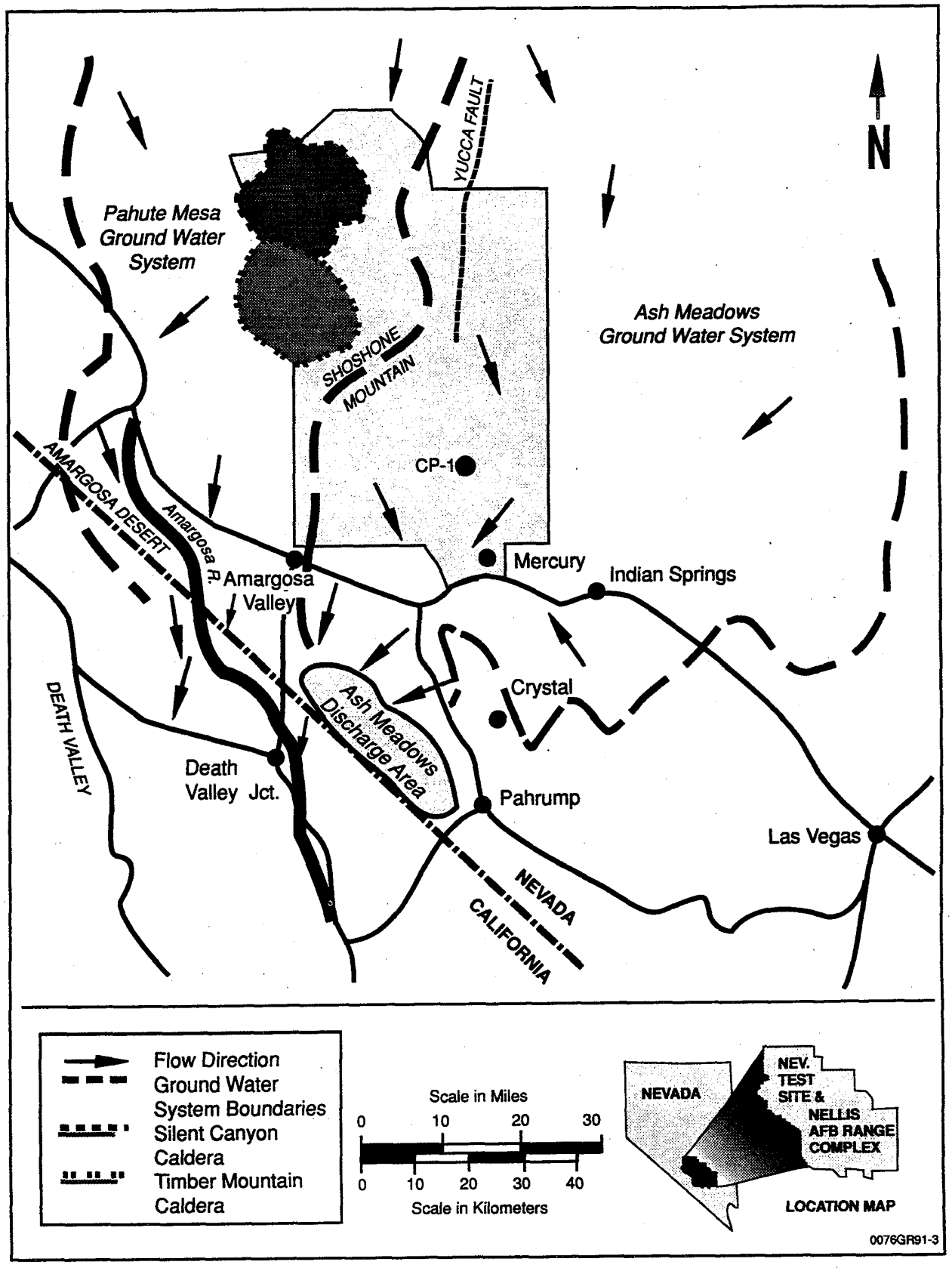

Figure 3. Ground water flow systems around the Nevada Test Site.

3.4 LAND USE OF NEVADA TEST SITE REGION

Figure 4 is a map of the off-NTS area showing a wide variety of land uses, such as farming, mining, grazing, camping, fishing, and hunting within a 180-mile (300-km) radius of the NTS operations control center, located at CP–1 (the location of CP–1 is shown on Figures 3 and 6). West of the NTS, elevations range from 280 feet (85 m) below MSL in Death Valley to 14,600 feet (4,420 m) above MSL in the Sierra Nevada Range. Parts of two major agricultural valleys (the Owens and San Joaquin) are included. The areas south of the NTS are more uniform since the Mojave Desert ecosystem (mid-latitude desert) comprises most of this portion of Nevada, California, and Arizona. The areas east of the NTS are primarily mid-latitude steppe with some of the older river valleys, such as the Virgin River Valley and Moapa Valley, supporting irrigation for small-scale but intensive farming of a variety of crops. Grazing is also common in this area, particularly to the northeast. The area north of the NTS is also mid-latitude steppe, where the major agricultural activity is grazing of cattle and sheep. Minor agriculture, primarily the growing of alfalfa hay, is found in this portion of Nevada within 180 miles (300 km) of the CP–1. Many of the residents have access to locally grown fruits and vegetables.

Recreational areas lie in all directions around the NTS (Figure 4) and are used for such activities as hunting, fishing, and camping. In general, the camping and fishing sites to the northwest, north, and northeast of the NTS are closed during winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the year. The peak of the hunting season is from September through January.

3.5 POPULATION DISTRIBUTION

Figure 5 shows the current population of counties surrounding the NTS based on 1990 Bureau of Census count (DOC90). Excluding Clark County, the major population center (approximately 741,459 in 1990), the population density of counties adjacent to the NTS is about 0.7 persons per square mile (0.4 persons per square kilometer). For comparison, the population density of the 48 contiguous states was 70.3 persons per square mile (27 persons per square kilometer) (1990 census). The estimated average population density for Nevada in 1980 was 1.1 persons per square mile (0.4 persons per square kilometer) (DOC86). Knowledge of population densities and spatial distribution of farm animals is necessary to assess protective measures required in the event of an accidental release of radioactivity at the NTS.

The offsite area within 48 miles (80 km) of CP–1 (the primary area in which the dose commitment must be determined for the purpose of this report) is predominantly rural. Several small communities are located in the area, the largest being in the Pahrump Valley. Pahrump, a growing rural community with a population of 7,425 (DOC90), is located 48 miles (80 km) south of the NTS CP–1. The small residential community of Crystal, NV, is also located in the Pahrump Valley, several miles north of the town of Pahrump. The location of Crystal, NV, is shown in Figure 3. The Amargosa farm area, which has a population of about 950, is located 30 miles (50 km) southwest of CP–1. The largest town in the near offsite area is Beatty, which has a population of about 1,500 and is located approximately 39 miles (65 km) to the west of CP–1.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service (NPS90) estimated that the population within the Monument boundaries ranges from a minimum of 200 permanent residents during the summer months to as many as 5,000 tourists and campers on any particular day during the major holiday periods in the winter months, and as many as 30,000 during "Death Valley Days" in the month of November. The next largest town and contiguous populated area, about 40 square miles (about 111 square km) in the Mojave Desert, is Barstow, CA, located 159 miles (265 km) south-southwest of the NTS, with a 1990 population count of 21,472. The largest populated area is the Ridgecrest, CA area, which has a current population of 27,725 and is located 114 miles (190 km) southwest of the NTS (DOC90). The Owens Valley, where numerous small towns are located, lies 30 miles (50 km) west of Death Valley. The largest town in the Owens Valley is Bishop, CA, located 135 miles (225 km) west-northwest of the NTS, with a population of 3,475 (DOC90).

The extreme southwestern region of Utah is more developed than the adjacent part of Nevada. The largest community is St. George, located 132 miles (220 km) east of the NTS, with a 1990 population count of 28,502. The next largest town, Cedar City, with a population of 13,443, is located 168 miles (280 km) east-northeast of the NTS (DOC90).

The extreme northwestern region of Arizona is mostly range land except for that portion in the Lake Mead Recreation Area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 99 miles (165 km) south-southeast of the NTS, with a 1990 population count of 21,951 and Kingman, located 168 miles (280 km) southeast of the NTS, with a population of 12,722 (DOC90). Figures 6 through 9 show the domestic animal populations in the counties near the NTS.

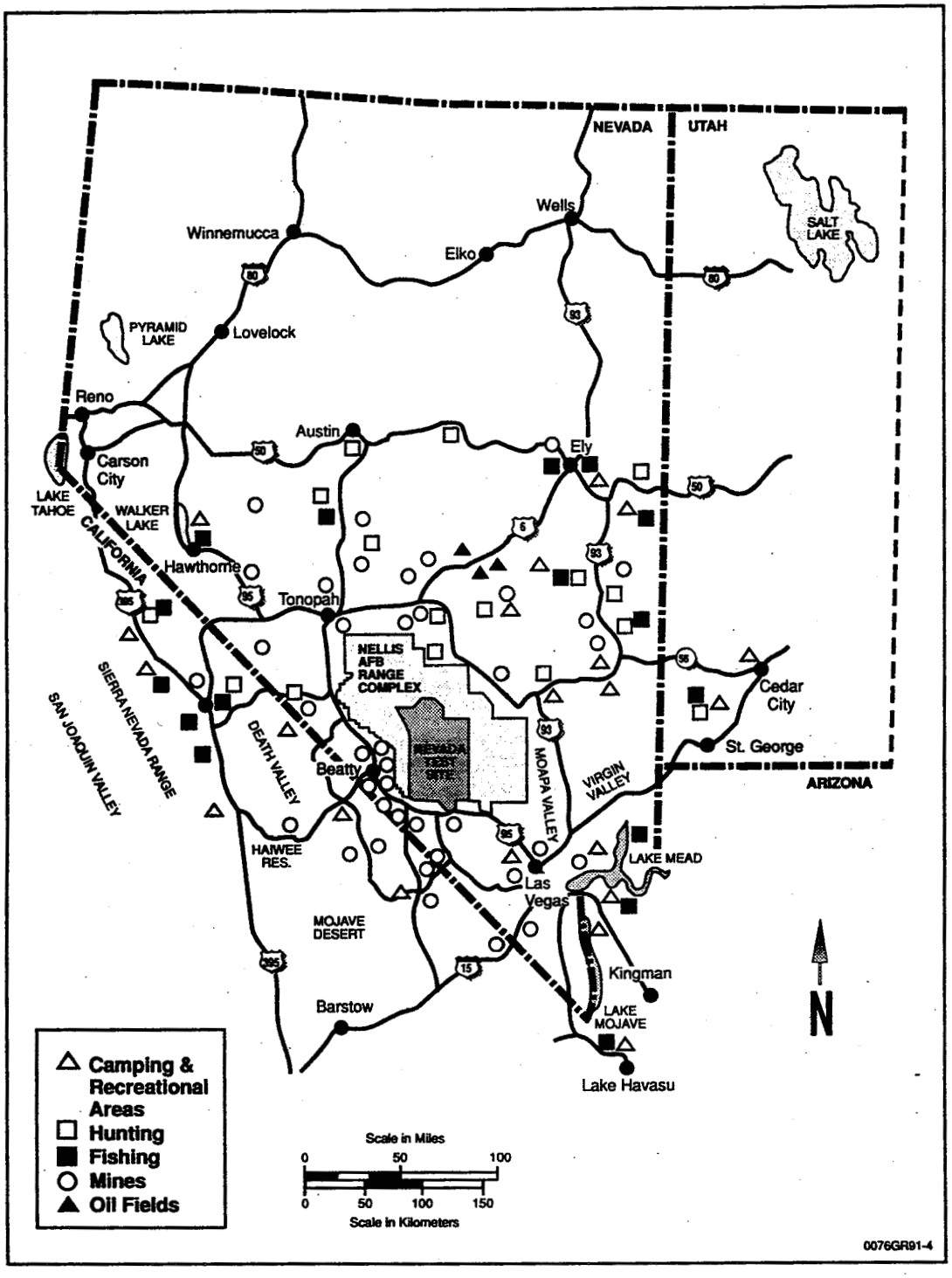

Figure 4. General land use within 180 miles (300 km) of the Nevada Test Site.

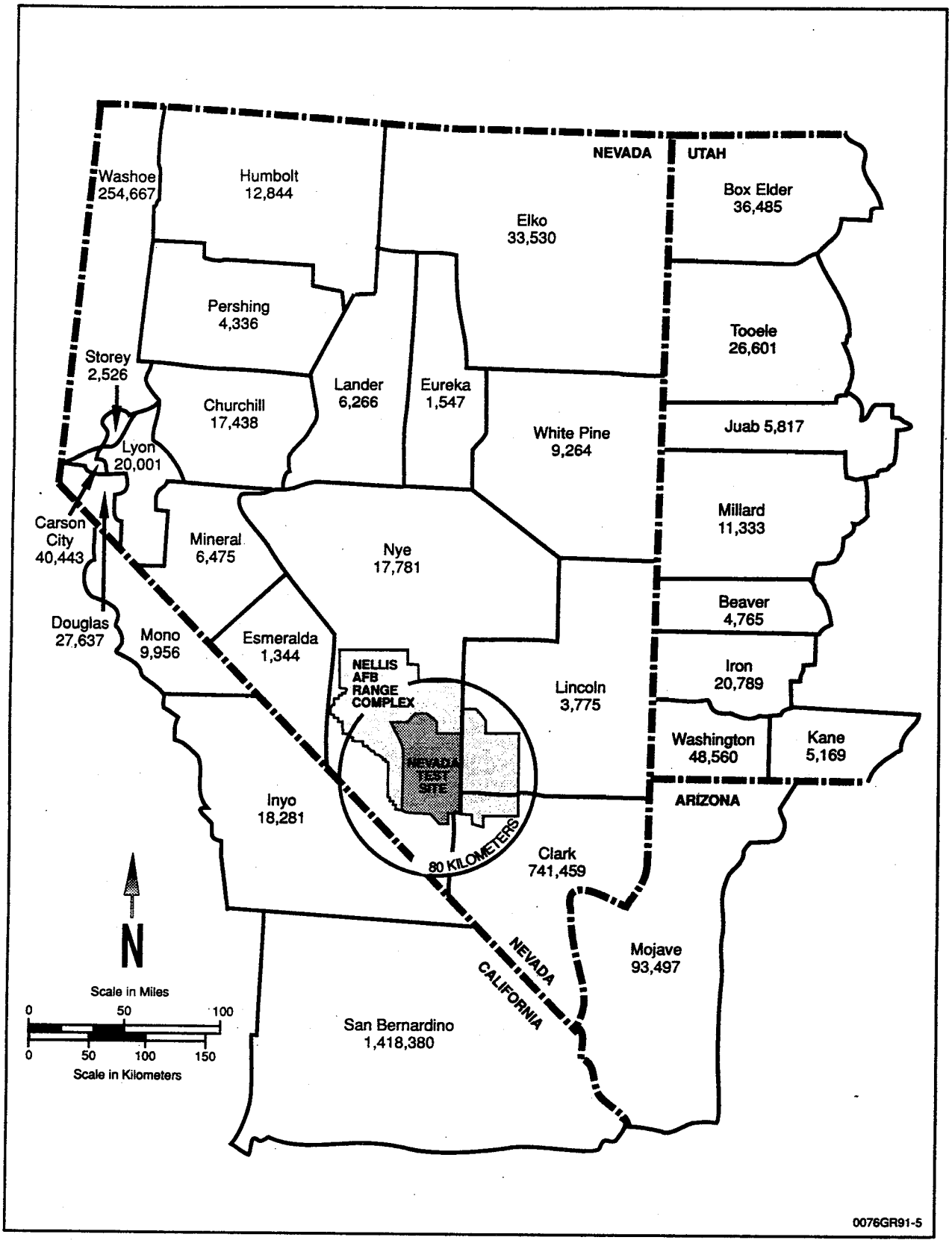

Figure 5. Population of Arizona, California, Nevada, and Utah counties near the Nevada Test Site (DOC90).

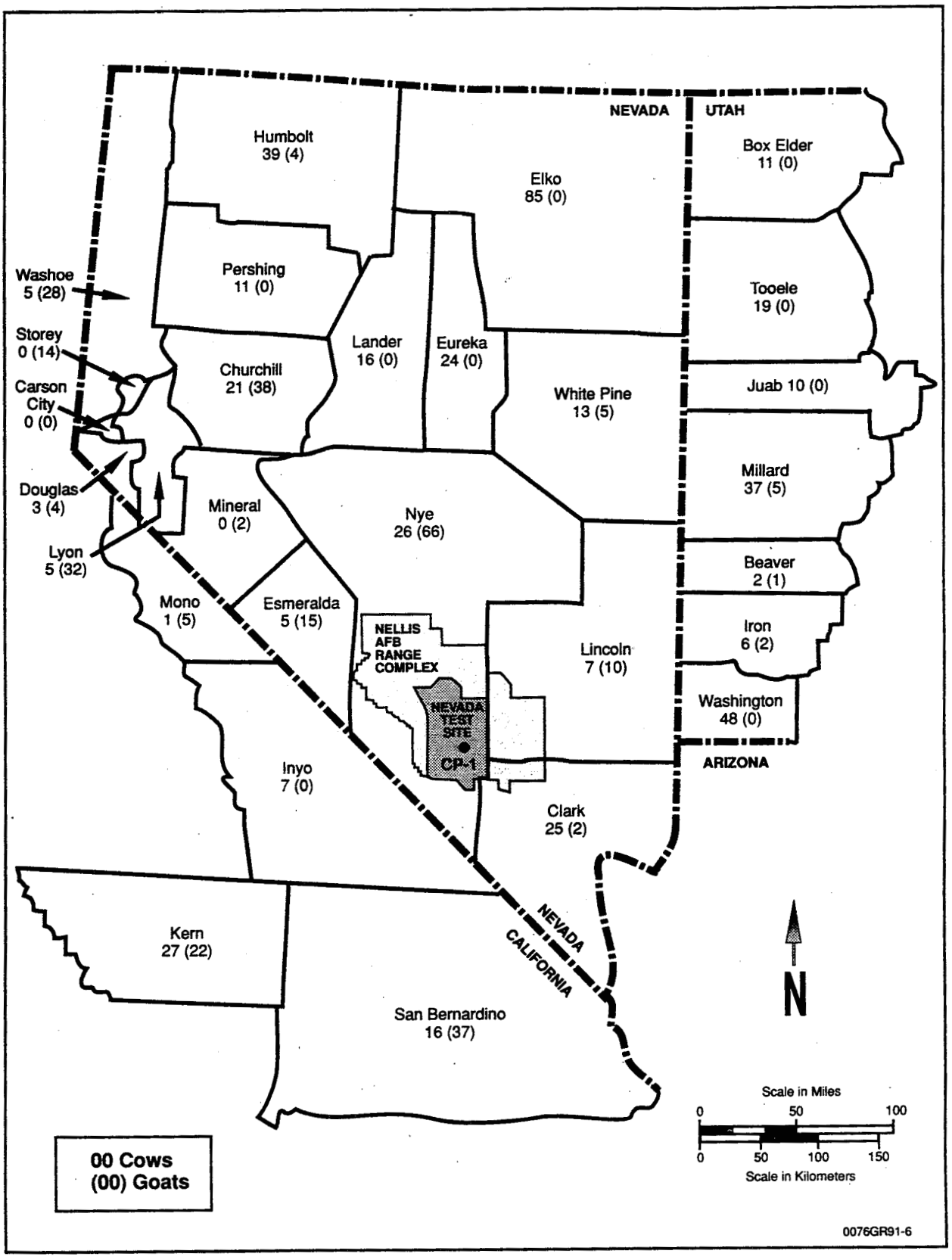

Figure 6. Distribution of family milk cows and goats, by county (DOC90).

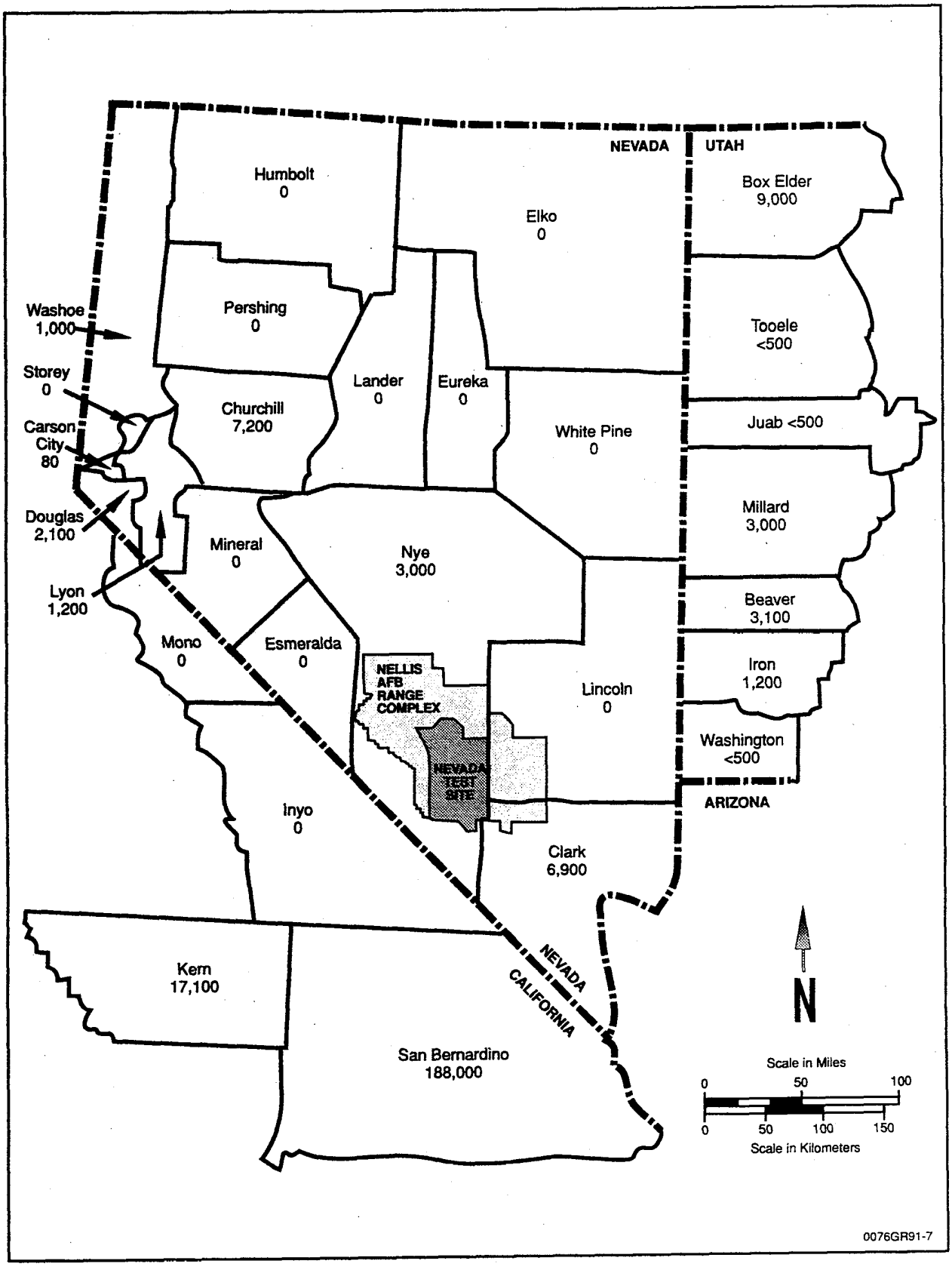

Figure 7. Distribution of dairy cows, by county (DOC90).

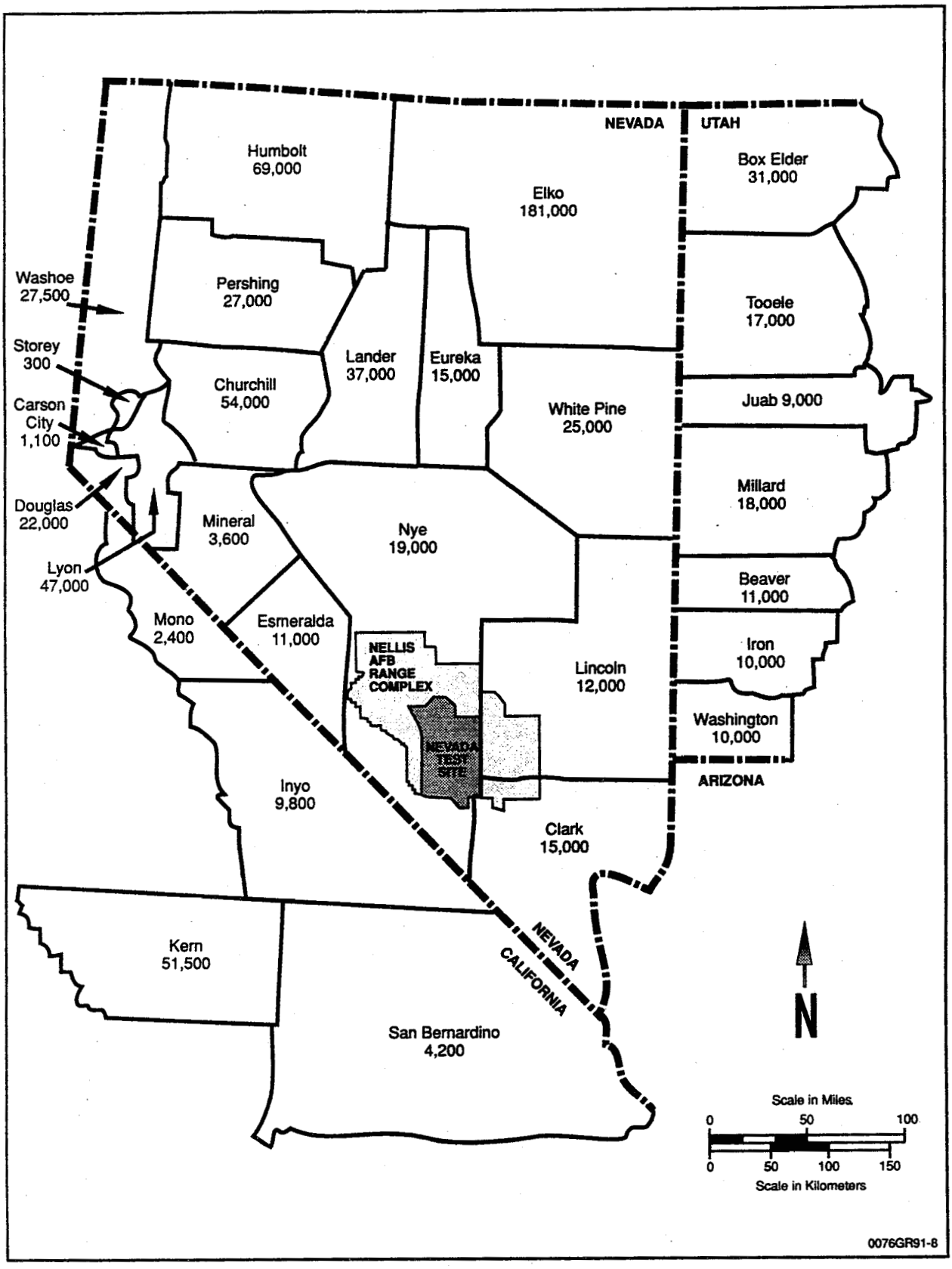

Figure 8. Distribution of beef cattle, by county (DOC90).

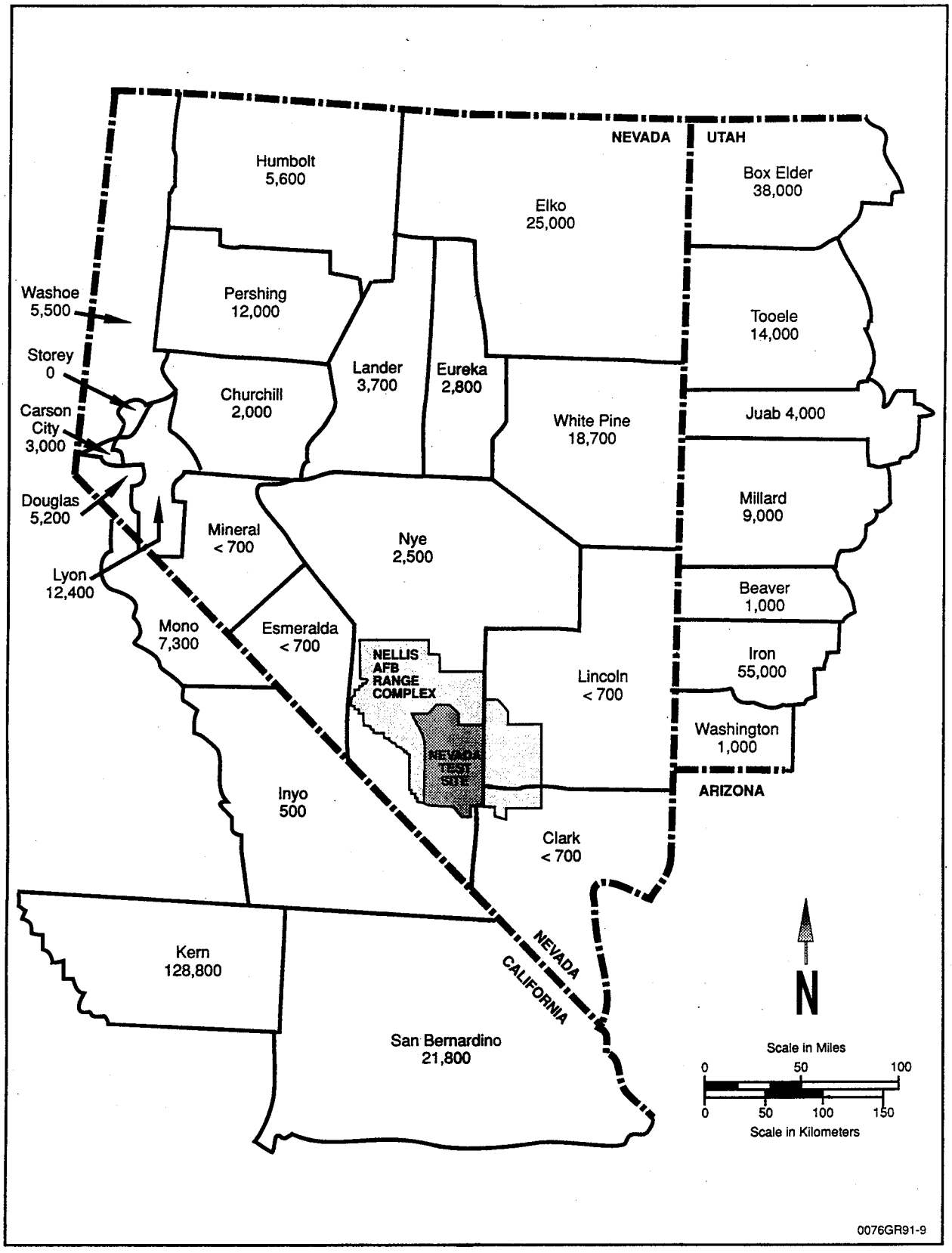

Figure 9. Distribution of sheep, by county (DOC90).

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4 Radiological Safety Activities

C. A. Fontana

The radiological safety activities of EMSL-LV are divided into two areas, both designed to detect environmental radiation: nuclear test support and routine environmental surveillance. Routine environmental surveillance includes pathways monitoring and internal and external exposure monitoring. Special environmental surveillance is performed when there is reason to expand the routine environmental surveillance due to public concern or special events such as the accident at Chernobyl U.S.S.R. in 1986. Data acquired from this surveillance provide a basis for assessing possible exposures to individuals or population groups. If an increase in environmental radiation occurs for which protective actions are necessary, specific remedial actions would be initiated to keep these exposures to a minimum. These activities are described in the following portions of this report.

4.1 NUCLEAR TEST SUPPORT

Prior to all nuclear tests, mobile monitoring teams are deployed around the NTS. They are prepared to assist in directing protective actions for offsite residents should that become necessary. Prior to each test, the teams determine the locations of residents, work crews, and domestic animal herds, and obtain information relative to residents in communities and remote areas. Monitoring technicians, equipped with a variety of radiation survey instruments, dosimeters, portable air samplers, and supplies for collecting environmental samples, are prepared to conduct a monitoring program as directed via two-way radio communications from CP-1 at the NTS (Figure 10). The radiological safety criteria, or protective action guides, used by EMSL-LV are based on those specified in NVO-176 (EPA91A).

Senior EPA personnel serve as members of the Test Controller's Advisory Panel to provide advice on possible public and environmental impact of each test and on feasible protective actions in the event that an accidental release of radioactivity should occur.

4.1.1 Remedial Actions

Remedial actions that EPA could recommend or implement to reduce whole-body exposures and the thyroid dose resulting from uptake of radionuclides in the food chain, particularly radioiodine in milk, include:

- evacuation.
- shelter.
- access control.
- livestock feeding practices control.
- milk control.
- food and water control (to a lesser degree).

Which action, if any, is feasible depends largely upon the type of accident and the magnitude of the projected exposures and doses, the response time available for carrying out the action, and local constraints associated with a specific site. Constraints vary, but include such factors as:

- Number of people and their distribution in the impacted area.
- Availability of transportation and condition of transportation routes.
- Season of the year.
- Existence of schools and hospitals.
- Availability and number of law enforcement personnel and state and county emergency services personnel.
- Presence of bedridden people or those unwilling to cooperate.

These factors, either alone or collectively, impact the effectiveness of remedial action.

An important factor affecting the efficacy of the remedial actions is the degree of credibility EPA

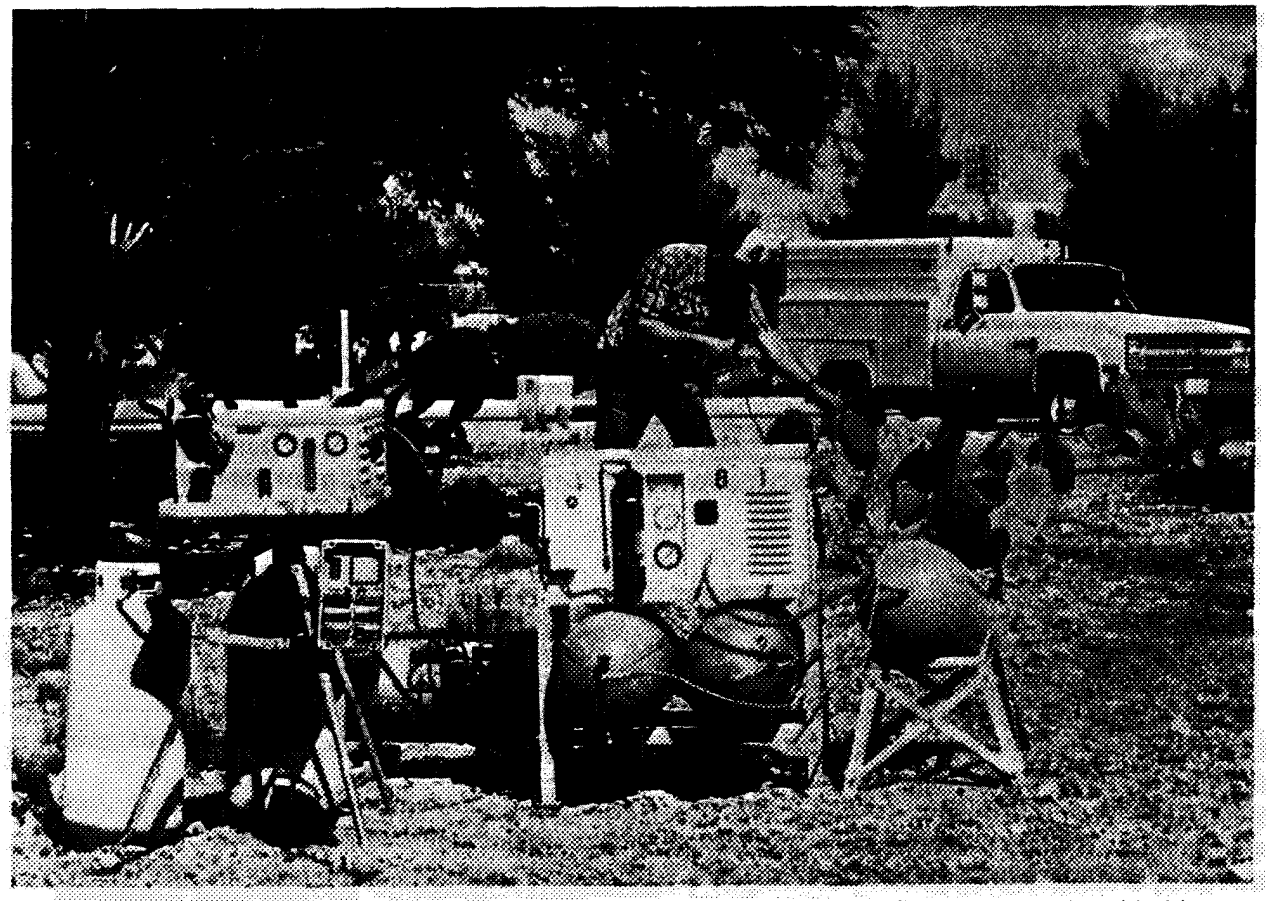

Figure 10. Monitoring Technician surveys ambient environmental radiation using a hand-held survey instrument. Foreground from left to right: constant flow air sampler, gamma exposure-rate recorder, and compressed noble gas sampler.

personnel maintain with offsite residents. Credibility is created and maintained by routine personal contacts made with local officials and law enforcement personnel as well as with the ranchers, miners, and others living in the offsite areas close to the NTS.

4.1.2 Remedial Actions to Minimize Whole-Body Exposure

To determine the feasible remedial actions for an area, EPA uses its best judgment based on experience gained during atmospheric tests and from those tests conducted in the 1960s that contaminated offsite areas. No remedial actions have been necessary since 1970, so there is no recent experience by which to test this judgment. However, through routine contact with offsite residents and through continuing population and road surveys, EPA maintains a sense of the degree to which it could implement remedial actions and the kind of cooperation that would be provided by officials and residents of the area (EPA91A).

If an underground nuclear test is expected to cause ground motion detectable offsite, EPA monitoring technicians are stationed at locations where hazardous situations might occur, such as underground mines. At these locations, occupants are notified of potential hazards so they can take precautionary measures.

EG&G Energy Measurements, Inc. cloud sampling and tracking aircraft are flown over the NTS to gather meteorological data and obtain samples, assess total cloud volume and content and provide long range tracking in the event of a release of airborne radioactivity. Information from these two aircraft can be used in positioning the mobile radiation monitoring technicians. During calendar year 1990, EMSL-LV personnel were deployed for all underground nuclear tests conducted at the NTS, none of which released radioactivity that could be detected offsite.

4.2 ROUTINE ENVIRONMENTAL SURVEILLANCE

The following subsections describe each of the major component programs of the ORSP. Network sampling locations, sampling and analysis procedures, and data results are described. Specific QA procedures and results are described in Chapter 6; Chapter 8 briefly describes analytical methods. Supplementary figures and tables are contained in the Appendix. These supplementary figures include box-and-whisker plots, which are described in Section 6.4.1.

4.2.1 Airborne Releases of Radioactivity at the Nevada Test Site during 1990

W.G. Phillips

All nuclear detonations during 1990 were conducted underground and were contained. Releases of low-level radioactivity occurred during re-entry drilling, seepage through fissures in the soil or purging of tunnel areas. Table 2 shows the quantities of radionuclides released to the environment, as reported by the DOE Nevada Operations Office (DOE90). Because these releases occurred throughout the year and because of the distance from the points of releases to the nearest offsite sampling station, none of the radioactive material listed in this table was detected offsite. Also listed are radionuclides found in drainage ponds onsite that remain in situ. Evaporation could contribute ^{3}H to the atmosphere, but the amounts were too small to be detected by the offsite network.

TABLE 2. RADIONUCLIDE EMISSIONS ON THE NEVADA TEST SITE DURING 1990

Grouped Sources

1. Ground seepage
2. Drillbacks & Tunnel Purging
3. Containment Pond Evaporation

RADIONUCLIDE	HALF-LIFE (DAYS)	QUANTITY RELEASED (Ci)
Emissions from Sources 1 and 2:		
^{3}H	4,510	698
^{37}Ar	34.8	2.42
^{39}Ar	98,200	1.3×10^{-3}
^{85}Kr	3,910	7.6×10^{-2}
^{131}I	8.05	1.3×10^{-3}
^{133}I	0.86	1.9×10^{-4}
^{131m}Xe	11.9	1.16
^{133m}Xe	2.19	1.84×10^{-1}
^{133}Xe	5.25	30.0
^{135}Xe	0.36	8.0×10^{-2}
Emissions from Source 3:		
^{3}H	4,510	670

To detect any radioactivity that might escape from the NTS, a routine surveillance program is conducted. This program includes pathway monitoring that consists of air, water, and milk surveillance networks surrounding the NTS and a limited animal sampling program. In addition, external and internal exposures of offsite populations are assessed using state-of-the-art dosimetry equipment. The following portions of this report detail the results of these surveillance programs.

4.2.2 Air Surveillance Network

V. E. Niemann

The ASN monitors an important pathway for human exposure to radionuclides, the inhalation of airborne materials (Figure 11). This network consists of 32 continuously operating air samplers (Figure 12) in areas surrounding the NTS and 78 standby air samplers (Figure 13), operated routinely on a quarterly schedule or more often, as needed. Each sampler draws air through a glass-fiber filter (for particulates) and a charcoal cartridge (for gaseous radioiodines) for one week. Both the filters and the charcoal cartridges are analyzed by gamma spectroscopy. The particulate filters are analyzed for gross beta activity, then selected filters are composited (combined and dissolved) for plutonium analysis. Only naturally occurring ^{7}Be was detected by gamma spectroscopy; the gross beta results were consistent with previous data; and one composited filter sample from Rachel, NV, contained a detectable amount of ^{238}Pu.

4.2.2.1 Network Design

Both the concentration and the source of airborne radioactivity must be determined if appropriate corrective actions are to be taken. The ASN is designed to monitor the areas within 210 miles (350 km) of the NTS. Station location is dependent upon the availability of electrical power and, at stations distant from the NTS, of a resident willing to operate the equipment. This continuously operating network is supplemented by the standby network, which covers the contiguous states west of the Mississippi River.

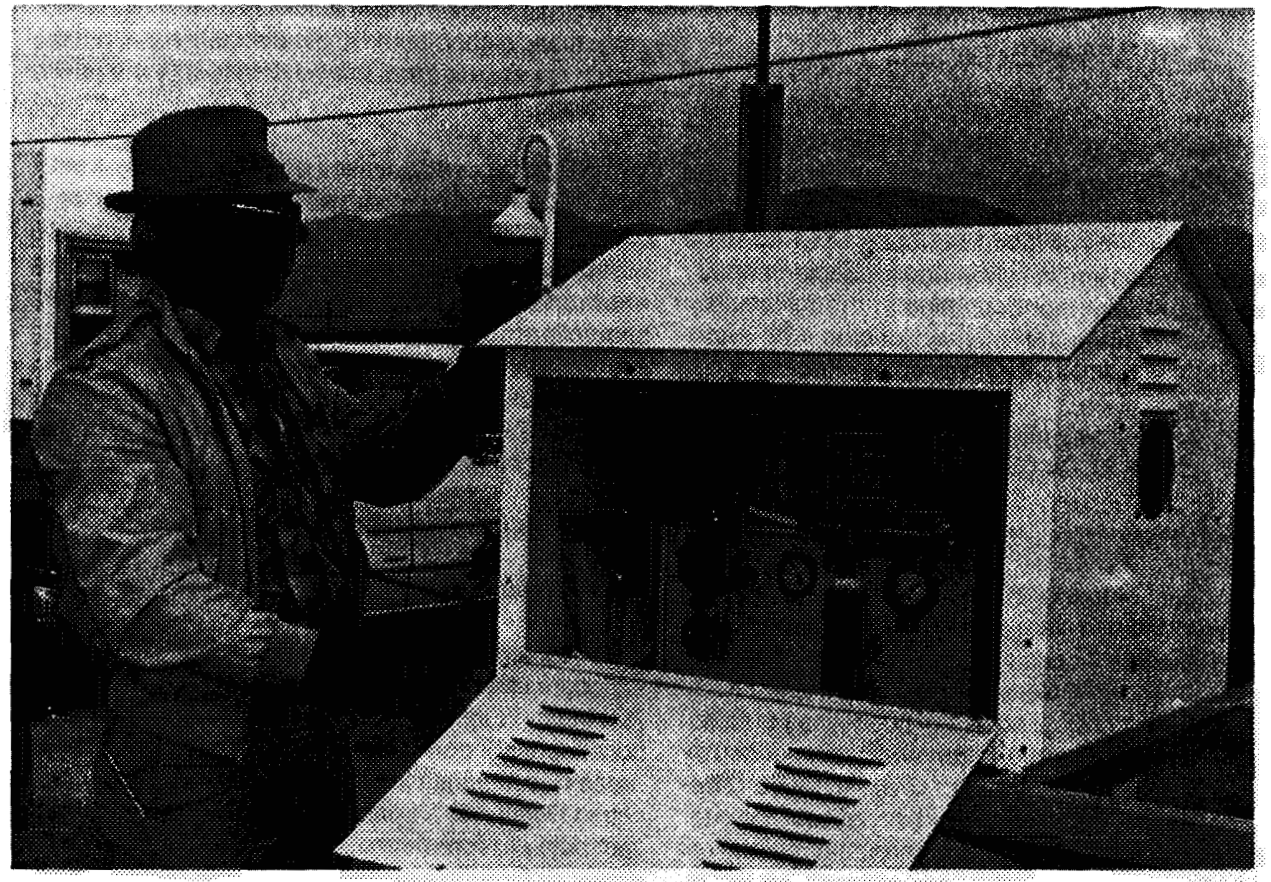

Figure 11. Monitoring Technician servicing air sampler at Pahrump Community Monitoring Station.

4.2.2.2 Methods

During 1990, air samples were collected from 32 continuously operating sampling stations and 75 of the 78 standby stations. Another station was added to the ASN late in 1990, making a total of 33 stations in the continuously operating network. The air sampler at each station was equipped to collect both particulate radionuclides on filters and gaseous radioiodines on charcoal. The filters and charcoal cartridges from all active stations and the filters from the standby stations were routinely analyzed.

Samples of airborne particulates were collected at each active station on 5-cm diameter glass-fiber filters at a flow rate of about 80 m^3 per day. Filters were changed after sampler operation periods of one week. Sample volumes of approximately 570 m^3 were collected during each sampling period; actual total sample volumes were measured with ± ten percent precision. Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodines were changed at the same time as the filters.

The standby network was activated for approximately one week per quarter. The standby samplers are identical to those used at the active stations and are operated by state and municipal health department personnel or by local residents. All analytical work was performed at EMSL-LV.

All air samples are initially analyzed by gamma spectrometry; each of the glass-fiber filters is then analyzed for gross beta activity after a 7- to 14-day delay to decrease the contribution from naturally occurring radon-thoron daughter activity. Gross beta analysis is used to detect trends in atmospheric radioactivity since it is more sensitive than gamma spectrometry for this purpose. Selected filters are then composited (combined) and are analyzed for plutonium. The analytical procedures used are described briefly in Chapter 8.

4.2.2.3 Quality Assurance/Quality Control

Quality assurance requirements for the gross beta, gamma, and plutonium analyses include:

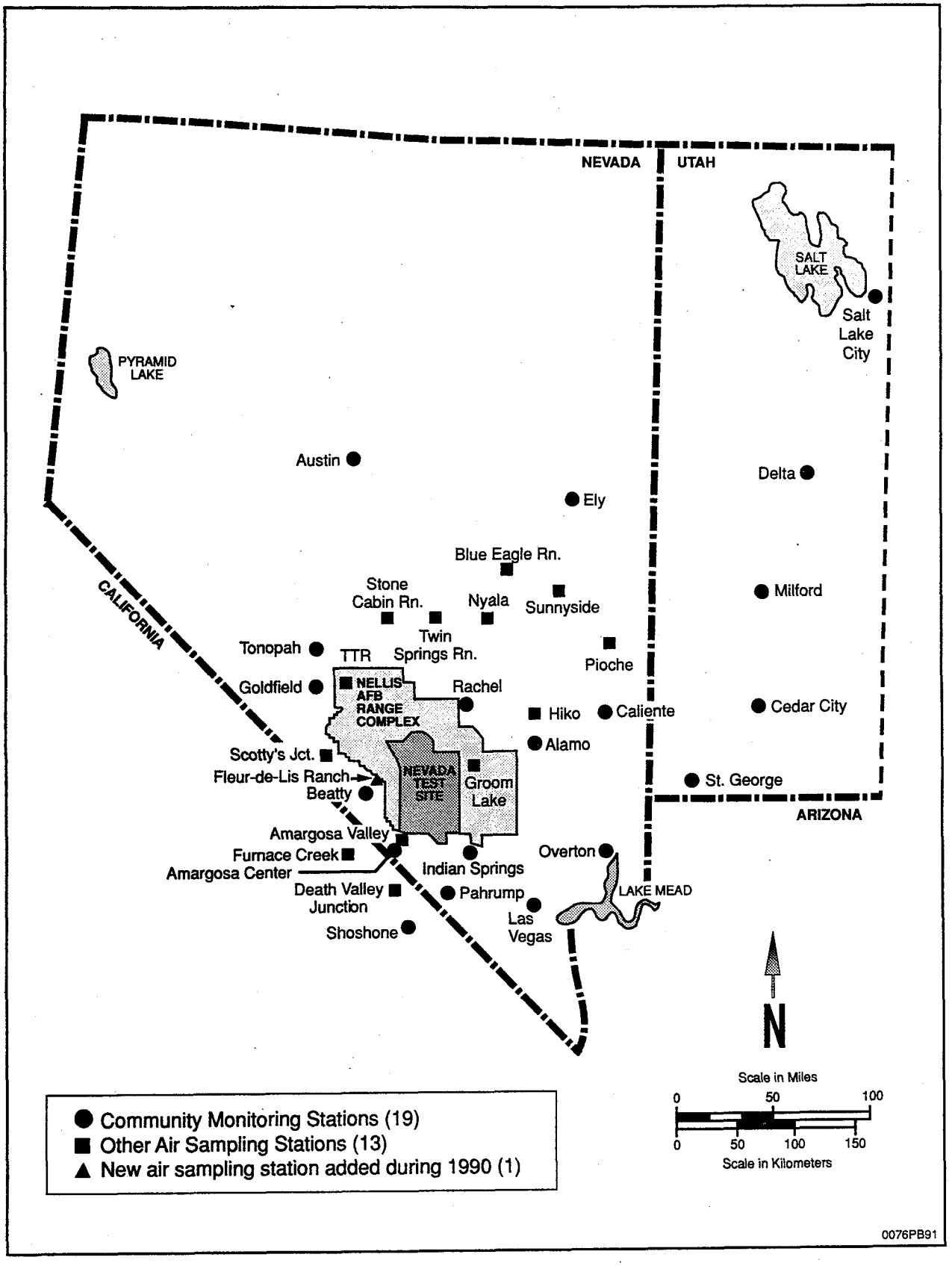

Figure 12. Air Surveillance Network stations (1990).

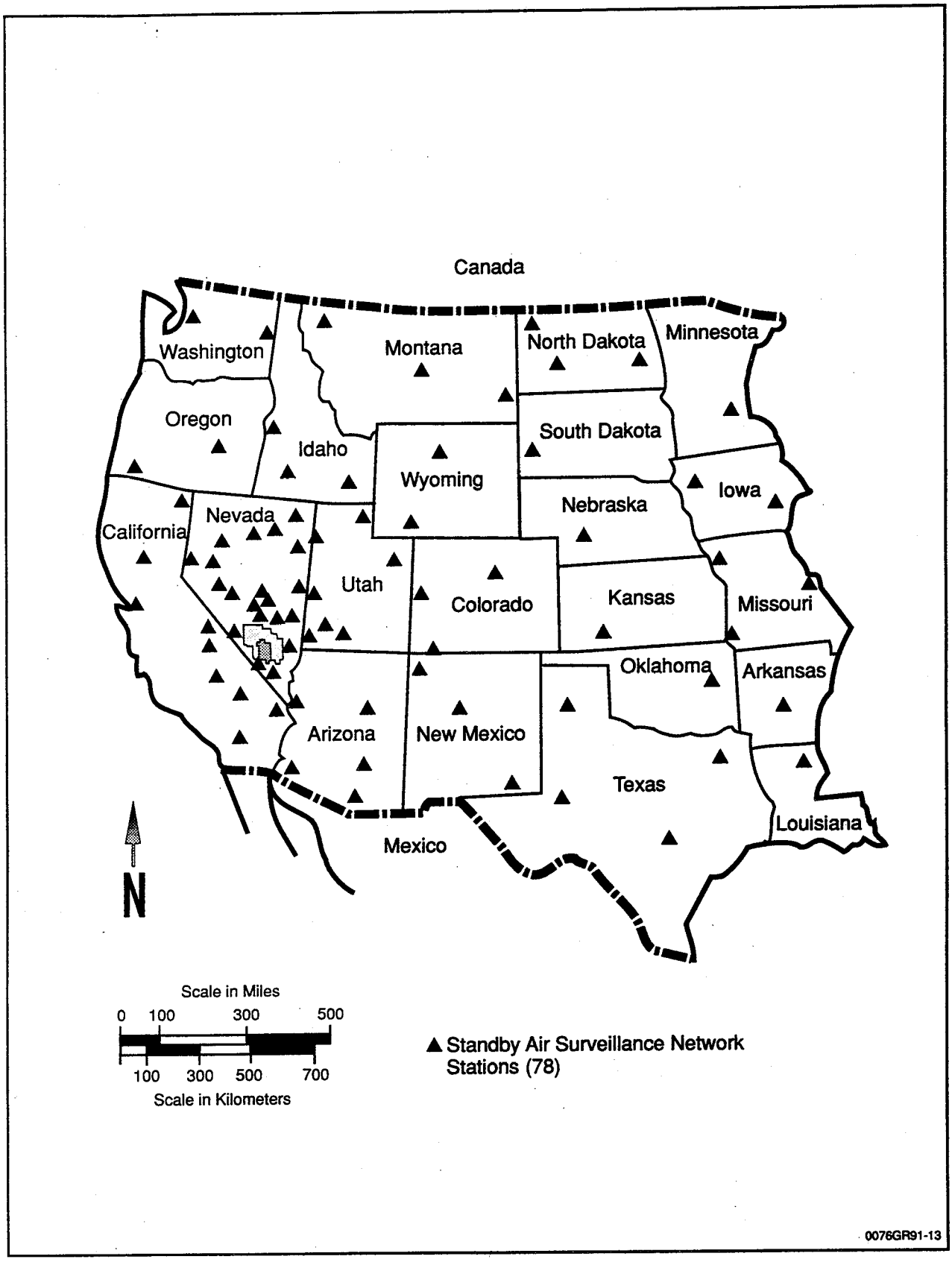

Figure 13. Standby Air Surveillance Network stations (1990).

- Maintaining a current calibration decal on all field sampling and laboratory instruments.
- Maintaining a file of calibration records, control charts, and log books for balances.
- Assigning unique sample numbers.
- Obtaining laboratory supervisor approval of all analytical results before they are entered into the permanent data base.
- Maintaining files of QA data, which includes raw analytical data, intermediate calculations, and review reports.

Quality control (QC) procedures include:

- Performing analysis of blanks to verify that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized.
- Estimating analytical accuracy with spiked samples. For the gamma analysis of fiber filters, spiked samples should be within ±20% of the known value. Gamma analysis of charcoal cartridges should be within ±20%. Gross beta should be within ±10%. Plutonium analysis internal spikes should produce results within ±20% of the known value.
- Estimating precision of laboratory analytical techniques and total precision for the entire system (both analytical and sampling error) by several methods, including replicate analyses.
- Determining bias (the difference between the data set mean value and the true, [i.e., reference], value) by intercomparison cross-check studies.

Chapter 6 provides detailed information on the QA program and 1990 QA and QC results.

4.2.2.4 Results

During 1990, no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from the ASN. Throughout the network, naturally occurring ^{7}Be was the only nuclide detected by gamma spectroscopy. The minimum and maximum concentrations were similar to previous results: –0.16 to 0.91 x 10^{-12} µCi/mL (–0.006 to 0.034 Bq/m^3). The principal means of ^{7}Be production is from spallation (splitting) of ^{16}O and ^{14}N by cosmic rays in the atmosphere.

The monthly average gross beta in air samples since 1981 from five stations in the network is plotted in Figure A1 (Appendix). These figures are box-and-whisker plots, described in Section 6.4.1. The data from the other stations are similar and suggest little significant difference among stations. A summary of the 1990 ASN data is shown in Table 3 and Table 4 for the standby stations.

The filters from the stations at Las Vegas, Lathrop Wells, and Rachel, NV, and Salt Lake City, UT, are composited as monthly samples and analyzed quarterly for plutonium. The other samples for plutonium analysis consist of composited filters from two stations in each state in which standby stations are located. Plutonium analyses are completed quarterly. The results of the ^{238}Pu and $^{239+240}Pu$ analyses from 14 states are shown in Table A1 (Appendix).

Concentrations of ^{238}Pu above the MDC were detected in one sample from Rachel, NV, and one sample from Las Vegas, NV, in 1990. Additionally, a single composite sample from Austin and Amarillo, TX, produced a $^{239+240}Pu$ concentration greater than the MDC. All three samples were near the MDC. With the exception of the Rachel sample, the results are considered to be within the expected five percent probability of false positives. The generally low results obtained for other samples from these locations over several years provides further support that these two results were false positives.

Occassional positive ^{238}Pu and $^{239+240}Pu$ results obtained at Rachel over the past three years indicate the need for additional sampling to characterize the area and to pinpoint the source of the very small amounts of plutonium in the air samples there. A sampling program for both Lathrop Wells and Rachel, NV, will be designed and undertaken during 1991 to accomplish this. High volume air samplers will be utilized, and soil sample analysis will be done. Also, because of the surface plutonium cleanup, which will occur at the NTS during the restoration efforts, and due to the prevailing wind patterns, air samples from the Alamo, Nevada, station will be analyzed routinely for ^{238}Pu and $^{239+240}Pu$.

TABLE 3. SUMMARY OF GROSS BETA ANALYSES FOR AIR SURVEILLANCE NETWORK CONTINUOUSLY OPERATING STATIONS — 1990

SAMPLING LOCATION	NO. DAYS SAMPLED[b]	GROSS BETA CONCENTRATIONS (10^{-12} µCi/mL)[a] MAX	MIN	AVG
DEATH VALLEY JCT CA	357	0.036	0.011	0.020
FURNACE CREEK CA	361	0.069	0.007	0.027
SHOSHONE CA	332	0.100	0.000	0.022
ALAMO NV	371	0.051	0.005	0.023
AMARGOSA CENTER NV	357	0.045	0.004	0.022
AUSTIN NV	351	0.043	0.008	0.020
BEATTY NV	350	0.041	0.011	0.022
BLUE EAGLE RANCH NV	362	0.041	0.008	0.019
CALIENTE NV	348	0.044	0.011	0.022
ELY NV	369	0.035	0.005	0.020
FALLINI'S TWIN SPGS RANCH NV	363	0.047	–0.002	0.022
FLEUR-DE-LIS RANCH NV[c]	56	0.027	0.003	0.017
GOLDFIELD NV	347	0.041	0.009	0.021
GROOM LAKE NV	347	0.039	0.002	0.019
HIKO NV	370	0.043	0.005	0.022
INDIAN SPRINGS NV	366	0.038	0.009	0.021
LAS VEGAS NV	371	0.046	0.011	0.023
LATHROP WELLS NV	369	0.041	0.002	0.019
NYALA NV	364	0.036	–0.003	0.014
OVERTON NV	370	0.051	0.011	0.024
PAHRUMP NV	370	0.039	0.008	0.020
PIOCHE NV	355	0.038	0.009	0.021
RACHEL NV	349	0.039	0.001	0.020
SCOTTY'S JCT NV	368	0.043	0.009	0.022
STONE CABIN RANCH NV	365	0.036	0.005	0.019
SUNNYSIDE NV	364	0.042	0.001	0.019
TONOPAH NV	370	0.034	0.004	0.019
TONOPAH TEST RANGE NV	365	0.047	–0.002	0.019
CEDAR CITY UT	364	0.043	–0.000	0.019
DELTA UT	355	0.072	0.011	0.026
MILFORD UT	356	0.068	0.002	0.023
SALT LAKE CITY UT	370	0.036	0.012	0.022
ST GEORGE UT	370	0.060	0.001	0.021

[a] *Multiply by 3.7 x 10^{10} to convert to Bq/m³.*
[b] *Number of days determined from dates of filter changes and, therefore, do not equal exactly 365.*
[c] *This station was added to the network late in the year.*

4.2.3 Noble Gas and Tritium Surveillance Network

V.E. Niemann

This network is designed to detect noble gas (^{85}Kr, ^{133}Xe, and ^{135}Xe) and ^{3}H emissions from the NTS. Samples were collected weekly at 16 noble gas sampling stations and 19 tritium stations during 1990. No activity attributable to the NTS was identified.

4.2.3.1 Network Design

Noble gases and ^{3}H are emitted from nuclear reactors, reprocessing facilities, and nuclear testing. Background levels of ^{85}Kr have slowly increased over time with the increased use of nuclear power and because of the radionuclide's relatively long half-life and tendency to remain in the atmosphere. Environmental levels of the xenons, with their very short half-lives, are normally below the MDC. Although ^{3}H has a half-life similar to ^{85}Kr, it is

TABLE 4. SUMMARY OF GROSS BETA ANALYSES FOR AIR SURVEILLANCE NETWORK STANDBY STATIONS — 1990

SAMPLING LOCATION	NO. DAYS SAMPLED	GROSS BETA CONC. (10^{-12} µCi/mL)* MAX	MIN	AVG
GLOBE AZ	29	0.036	0.022	0.026
KINGMAN AZ	21	0.038	0.017	0.026
TUCSON AZ	29	0.022	0.016	0.019
WINSLOW AZ	35	0.054	0.015	0.029
YUMA AZ	28	0.034	0.010	0.024
LITTLE ROCK AR	28	0.025	0.017	0.021
ALTURAS CA	30	0.024	0.005	0.015
BAKER CA	26	0.046	0.016	0.029
BISHOP CA	32	0.050	0.014	0.027
CHICO CA	28	0.026	0.011	0.017
INDIO CA	14	0.027	0.014	0.021
LONE PINE CA	26	0.059	0.018	0.032
NEEDLES CA	28	0.015	0.007	0.010
RIDGECREST CA	34	0.024	0.012	0.016
SANTA ROSA CA	28	0.013	0.007	0.008
CORTEZ CO	21	0.029	0.015	0.023
DENVER CO	21	0.024	0.011	0.018
GRAND JCT CO	20	0.044	0.025	0.036
MOUNTAIN HOME ID	28	0.050	0.015	0.026
NAMPA ID	28	0.018	0.012	0.015
POCATELLO ID	28	0.025	0.011	0.020
FORT DODGE IA	35	0.043	0.010	0.027
IOWA CITY IA	28	0.044	0.020	0.031
DODGE CITY KS	21	0.035	0.014	0.022
MONROE LA	35	0.037	0.014	0.023
MINNEAPOLIS MN	21	0.025	0.014	0.019
CLAYTON MO	35	0.044	0.018	0.032
JOPLIN MO	28	0.041	0.021	0.029
ST JOSEPH MO	31	0.026	0.017	0.022
GREAT FALLS MT	21	0.019	0.009	0.015
KALISPELL MT	28	0.031	0.003	0.018
MILES CITY MT	28	0.032	0.012	0.021
ADAVEN NV	41	0.029	0.008	0.016
BATTLE MOUNTAIN NV	30	0.020	0.014	0.017
BLUE JAY NV	20	0.047	0.019	0.036
CLARK STATION NV	13	0.026	0.023	0.025
CURRANT NV ANGLE WORM RANCH	58	0.037	0.016	0.024
CURRIE NV - CURRIE MAINTENANCE STATION	30	0.021	0.011	0.015
DUCKWATER NV	23	0.029	0.022	0.025
ELKO NV PHILLIPS 66 TRUCK STOP	35	0.029	0.007	0.017
EUREKA NV	35	0.027	0.015	0.020
FALLON NV	14	0.061	0.027	0.044
GEYSER RANCH NV	28	0.033	0.009	0.018
LOVELOCK NV	20	0.026	0.011	0.017
LUND NV	22	0.019	0.010	0.015
MESQUITE NV	27	0.024	0.005	0.017
RENO NV	14	0.014	0.008	0.011
ROUND MOUNTAIN NV	29	0.032	0.012	0.021
WELLS NV	29	0.032	0.017	0.021
WINNEMUCCA NV	28	0.022	0.012	0.017
ALBUQUERQUE NM	20	0.032	0.023	0.027
CARLSBAD NM	27	0.026	0.009	0.017
SHIPROCK NM	12	0.020	0.020	0.020
BISMARK ND	28	0.032	0.013	0.025
FARGO ND	21	0.041	0.028	0.036
WILLISTON ND	28	0.041	0.023	0.031
MUSKOGEE OK	41	0.043	0.020	0.026
BURNS OR	28	0.019	0.004	0.012
MEDFORD OR	29	0.013	0.004	0.009
RAPID CITY SD	29	0.046	0.022	0.030
AMARILLO TX	7	0.046	0.046	0.046
AUSTIN TX	22	0.016	0.014	0.015
MIDLAND TX	21	0.010	0.002	0.006
TYLER TX	33	0.021	0.020	0.020
BRYCE CANYON UT	21	0.038	0.018	0.025
ENTERPRISE UT	21	0.018	0.015	0.017
GARRISON UT	36	0.030	0.014	0.023
LOGAN UT	29	0.076	0.012	0.033
PAROWAN UT	21	0.045	0.019	0.029
VERNAL UT	21	0.043	0.011	0.024
WENDOVER UT	30	0.023	0.006	0.016
SEATTLE WA	28	0.020	0.001	0.012
SPOKANE WA	28	0.049	0.006	0.022
ROCK SPRINGS WY	29	0.023	0.013	0.016
WORLAND WY	28	0.041	0.005	0.019

* *Multiply by 3.7×10^{10} to convert to Bq/m³.*

dynamically distributed among the air, surface and ground water, and soil. Environmental tritiated water (HTO) in air levels are normally below the MDC.

The NGTSN is designed to detect an increase in background levels of all of these radionuclides due to possible NTS emissions. Network samplers, as shown in Figure 14, are typically located in populated areas surrounding the NTS. To provide complete and indepth coverage in the downwind sector, some samplers are located in communities at some distance from the NTS, as indicated in Figure 15. In 1990, samples were collected from 16 noble gas sampling sites and 19 atmospheric moisture sampling sites located in the states of Nevada, Utah, and California. Atmospheric moisture collectors for tritium analyses

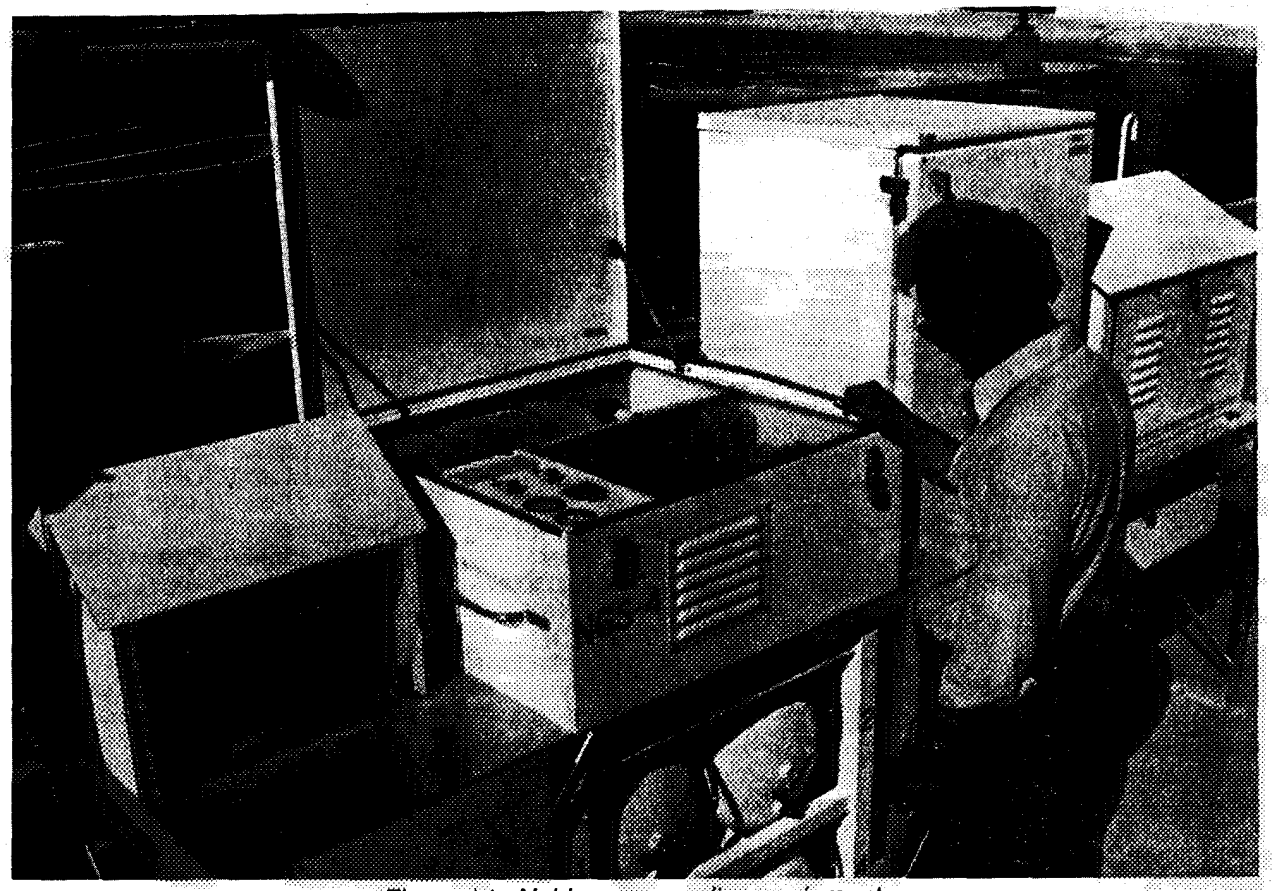

Figure 14. Noble gas sampling equipment.

located in Milford and Delta, UT, are on standby, so there are a total of 21 locations in the network equipped to sample atmospheric moisture.

4.2.3.2 Methods

Noble gas samples are collected by compressing air into storage tanks. Air is continuously sampled over a 7-day period and approximately 0.6 m^3 of air is collected. The tanks are returned to EMSL-LV for contents analysis. For the analysis, samples are condensed at liquid nitrogen temperature. Gas chromatography is then used to separate the various radionuclides. The radioactive gases are dissolved in chemical "cocktails" to prepare them for liquid scintillation counting (Chapter 8).

For ^3H concentration in atmospheric moisture, a column filled with molecular sieve pellets are used to collect water from the air (Figure 16). Up to 10 m^3 of air is pulled through the column over a 7-day sampling period. Water absorbed in the molecular sieve pellets is recovered, and the concentration of ^3H in the water is determined by liquid scintillation counting (Chapter 8). The measured amount of water in the sample is then used, along with the ^3H measurement, to calculate the concentration of HTO, the vapor form of tritium. This is the most commonly encountered form of tritium in the environment.

4.2.3.3 Quality Assurance/Quality Control

Quality assurance requirements for noble gas and tritium analysis include:

- Maintaining a current calibration decal on all field sampling and laboratory instruments.
- Maintaining a file of calibration records, control charts, and log books for balances.
- Assigning unique sample numbers.
- Obtaining laboratory supervisor approval of all analytical results before they are entered into the permanent data base.
- Maintaining files of QA data, which includes raw analytical data, intermediate calculations, and review reports.

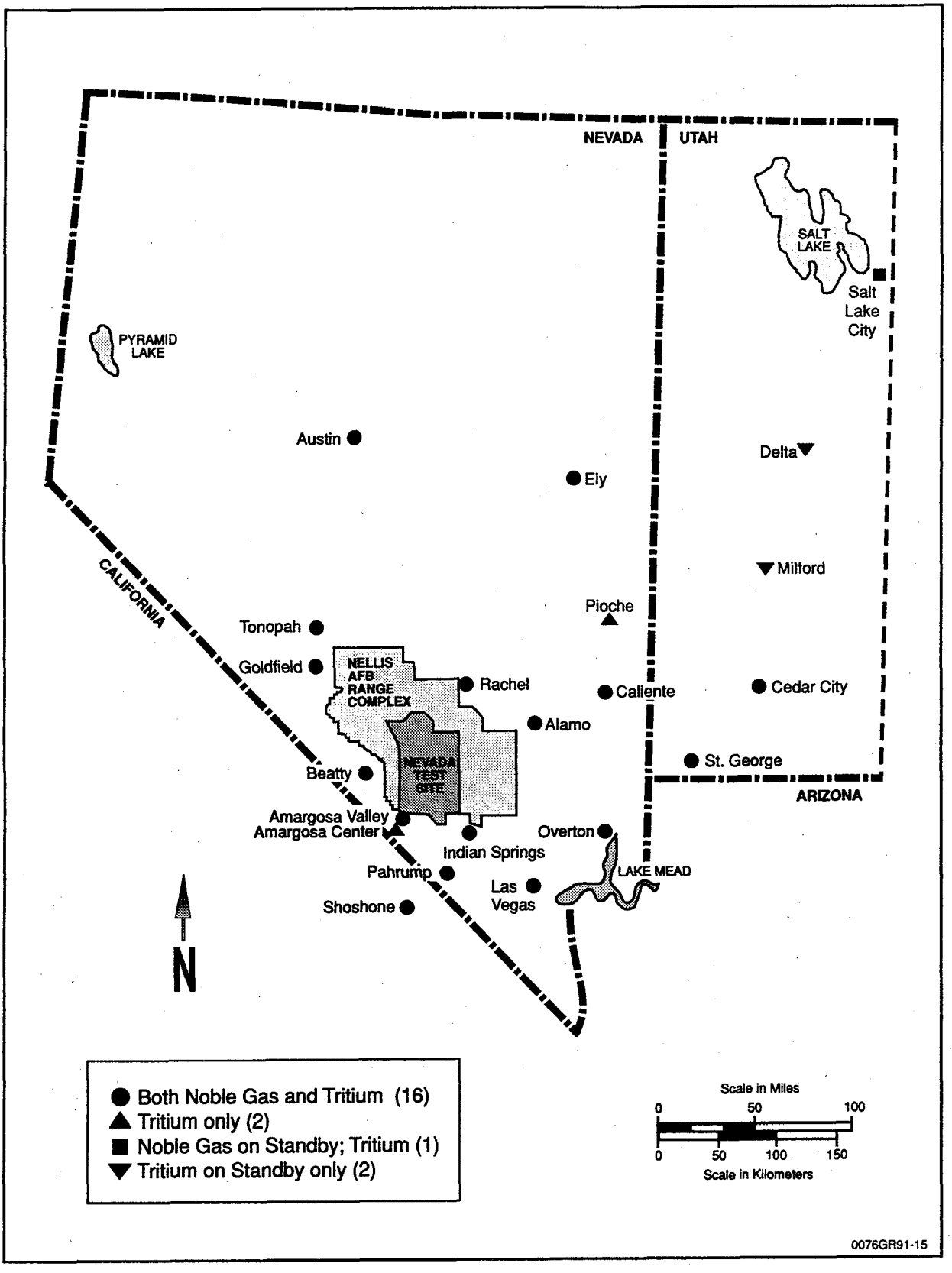

Figure 15. Noble Gas and Tritium Surveillance Network sampling locations (1990).

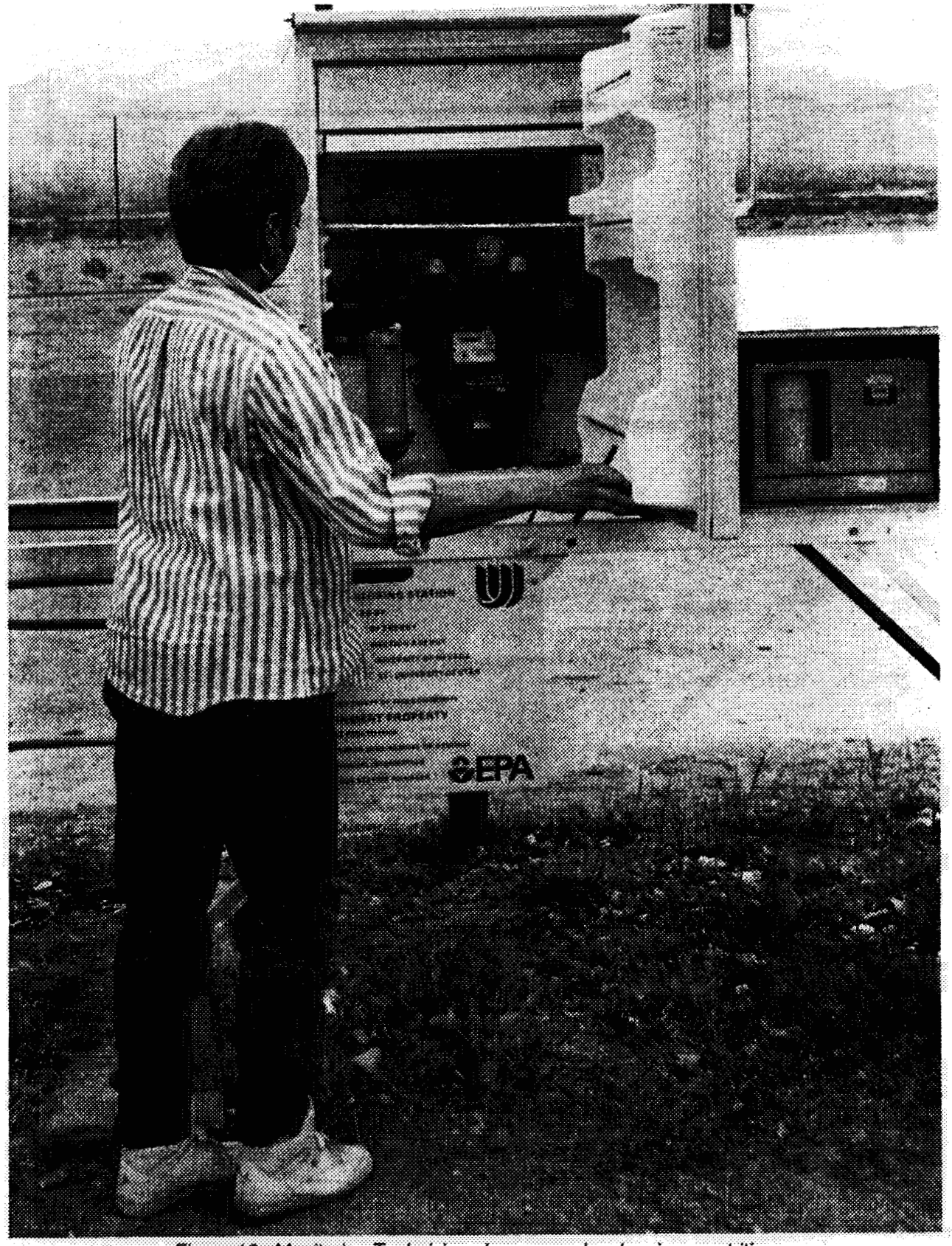

Figure 16. Monitoring Technician changes molecular sieve on tritium air sampler at Community Monitoring Station.

Quality control procedures include:

- Performing analysis of blanks to verify that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized.

- Estimating analytical accuracy with spiked samples (the content of which is unknown to the technicians). For the noble gases, spiked samples should be within ±20% of the known value. Tritium should be within ±10%.

- Estimating precision of laboratory analytical technique by analysis of duplicate samples.

- Determining bias (the difference between the data set mean value and the true [i.e., reference] value) by intercomparison cross check studies.

Chapter 6 provides more information on the QA program and results.

4.2.3.4 Results

While none of the ^{133,135}Xe results exceeded the MDC, the ^{85}Kr results always exceed the MDC due to the presence of an enhanced background. The results are, however, within the range expected.

Sample results for the NGTSN are summarized in Tables 5 and 6 for all sampling locations. This summary consists of the maximum, minimum, and average concentration for each station. The number of samples analyzed is typically less than the expected number (52) since samples are sometimes lost in analysis, or, due to equipment failure, an insufficient sample volume is collected. Network weekly averages for ^{85}Kr concentrations measured in 1990 are shown in Figure 17.

The measured ^{85}Kr concentrations ranged from 2.0 to 3.3 x 10^{-11} µCi/mL (0.74 to 1.2 Bq/m^3). A historical summary of data for this network shows an increasing trend over time. Network average ^{85}Kr results for the past ten years are shown in Table 7, while results for the period 1972-1990 are plotted in Figure 18.

The average concentration for the network in 1990 was 2.6 x 10^{-11} µCi/mL (0.98 Bq/m^3). This network average concentration, as shown in Figure 18, has gradually increased from the time sampling began in 1972 to the present. The historical increase reflects the worldwide increase in ambient concentrations resulting from the increased use of nuclear technology. There is no evidence in the 1990 ^{85}Kr results to indicate that the radioactivity detected resulted from current activities conducted at the NTS. Figure A2 (Appendix) displays box-and-whisker plots for network stations. An explanation of box-and-whisker plots is in Section 6.4.1. The general increasing trend appears to be present, although the high degree of variability in the data preclude a definitive conclusion.

The analysis results for the 841 xenon samples counted were all below the MDC; the MDC varied, but was generally about 1.4 x 10^{-11} µCi/mL (0.5 Bq/m^3).

As in the past, HTO concentrations in atmospheric moisture samples from the sampling stations were generally below the average MDC of about 4.6 x 10^{-12} µCi/mL (0.17 Bq/m^3) of air (Table 6). Of the 1,003 tritium network samples analyzed in 1990, six exceeded the MDC slightly. When counting samples with very low activities, false positive results are expected about five percent of the time. Results that slightly exceed the MDC may be true indicators of some slight elevation in activity levels or could be a result of statistical counting variations. The range of HTO concentrations is considered to be representative of statistical variations in counting background samples and not indicative of the presence of increased tritium levels in the environment.

In conclusion, the sampling network found no detectable increase in noble gas or tritium levels which could be attributed to activities at the NTS during 1990.

4.2.4 Milk Surveillance Network

A.A. Mullen

Milk is particularly important in assessing levels of radioactivity in a given area and, especially, the exposure of the population as a result of ingesting milk or milk products. It is one of the most universally consumed foodstuffs and certain radionuclides from any source are readily traceable through the food chain from feed/forage to consumer. Accordingly, milk is closely monitored by EMSL-LV through two intensive and interrelated networks: the MSN and the Standby Milk Surveillance Network (SMSN).

TABLE 5 . SUMMARY OF ANALYTICAL RESULTS FOR THE NOBLE GAS SURVEILLANCE NETWORK — 1990

SAMPLING LOCATION	NUMBER SAMPLES ANALYZED	RADIONUCLIDE	RADIOACTIVITY CONCENTRATION ($10^{-12}\mu Ci/mL$)[a] MAX	MIN	AVG	PERCENT OF CONCENTRATION GUIDE[b]
SHOSHONE CA	49	^{85}Kr	33	20	26	0.004
	49	^{133}Xe	4.5	–14	–0.20	<0.01
ALAMO NV	50	^{85}Kr	31	21	26	0.004
	51	^{133}Xe	8.3	–16	0.25	<0.01
AUSTIN NV	49	^{85}Kr	31	21	27	0.004
	49	^{133}Xe	11	–9.4	0.21	<0.01
BEATTY NV	52	^{85}Kr	32	21	26	0.004
	52	^{133}Xe	9.0	–9.2	–0.09	<0.01
CALIENTE NV	46	^{85}Kr	32	21	26	0.004
	47	^{133}Xe	11	–12	–0.23	<0.01
ELY NV	50	^{85}Kr	32	20	27	0.004
	50	^{133}Xe	11	–13	0.34	<0.01
GOLDFIELD NV	50	^{85}Kr	32	20	27	0.004
	52	^{133}Xe	8.0	–12	0.32	<0.01
INDIAN SPRINGS NV	52	^{85}Kr	30	21	27	0.004
	52	^{133}Xe	8.4	–8.1	0.26	<0.01
LAS VEGAS NV	47	^{85}Kr	33	20	26	0.004
	47	^{133}Xe	4.5	–5.6	–0.28	<0.01
LATHROP WELLS NV	50	^{85}Kr	33	22	26	0.004
	50	^{133}Xe	12	–10	–0.17	<0.01
OVERTON NV	50	^{85}Kr	32	22	26	0.004
	51	^{133}Xe	9.2	–12	0.15	<0.01
PAHRUMP NV	49	^{85}Kr	30	21	26	0.004
	50	^{133}Xe	7.7	–9.4	0.06	<0.01
RACHEL NV	49	^{85}Kr	32	21	27	0.004
	52	^{133}Xe	10	–14	–0.46	<0.01
TONOPAH NV	49	^{85}Kr	31	22	26	0.004
	51	^{133}Xe	16	–11	–0.66	<0.01
CEDAR CITY UT	49	^{85}Kr	32	21	26	0.004
	49	^{133}Xe	9.0	–11	–0.13	<0.01
ST GEORGE UT	48	^{85}Kr	31	20	27	0.004
	49	^{133}Xe	6.3	–7.8	–0.48	<0.01

[a] *The units used in this table ($10^{-12}\mu Ci/mL$) are equal to, and the values in the table may be read as, pCi/m^3.*

[b] *The concentration guide referenced is 40CFR61, subpart H. The maximum dose allowable to a resident in the environment surrounding a DOE facility is 10 mrem per year from air emissions (all pathways). The percent of the concentration guides were calculated assuming the respiration rate of standard man (ref ICRP-23) for a continuous exposure over a 1-year period.*

TABLE 6. SUMMARY OF ANALYTICAL RESULTS FOR CONCENTRATIONS OF TRITIATED WATER VAPOR IN AIR — 1990

SAMPLING LOCATION	NUMBER SAMPLES ANALYZED	RADIOACTIVITY CONCENTRATION (10^{-12} µCi/mL)[a]			PERCENT OF CONCENTRATION GUIDE[b]
		MAX	MIN	AVG	
SHOSHONE CA	53	5.4	–4.6	0.5	<0.01
ALAMO NV	50	13	–3.8	1.0	<0.01
AMARGOSA CENTER NV	8	8.3	–2.7	0.8	<0.01
AMARGOSA VALLEY NV	50	5.3	–3.1	0.2	<0.01
AUSTIN NV	52	4.6	–2.3	0.5	<0.01
BEATTY NV	52	3.3	–1.8	0.2	<0.01
CALIENTE NV	51	8.3	–2.7	1.3	<0.01
ELY NV	51	7.5	–1.5	0.7	<0.01
GOLDFIELD NV	50	16	–9.1	0.4	<0.01
INDIAN SPRINGS NV	48	2.8	–5.0	0.1	<0.01
LAS VEGAS NV	53	2.8	–2.1	0.4	<0.01
OVERTON NV	52	7.2	–3.3	0.9	<0.01
PAHRUMP NV	52	12	–5.2	0.5	<0.01
PIOCHE NV	51	5.1	–6.2	0.6	<0.01
RACHEL NV	51	10	–4.0	0.5	<0.01
TONOPAH NV	52	10	–4.6	0.9	<0.01
CEDAR CITY UT	52	5.0	–4.9	0.4	<0.01
ST. GEORGE UT	51	4.5	–2.3	0.6	<0.01
SALT LAKE CITY UT	49	6.4	–2.0	0.6	<0.01

[a] *The units used in this table (10^{-12} µCi/mL) are equal to, and the values in the table may be read as, pCi/m³.*
[b] *The concentration guide referenced is 40CFR61, subpart H. The maximum dose allowable to a resident in the environment surrounding a DOE facility is 10 mrem per year from air emissions (all pathways). The percent of the concentration guides were calculated assuming the respiration rate of standard man (ref ICRP-23) for a continuous exposure over a 1-year period.*

Data results for 1990 indicate no activity in milk samples related directly to current NTS activities.

4.2.4.1 Network Design

The MSN consists of 26 locations at which samples of raw milk are collected from either privately owned or commercial dairy milk cows and goats. These locations are within a 180-mile (300-km) radius of the NTS to maintain timely surveillance for radioactivity that may result from the NTS nuclear testing program.

The SMSN consists of 109 sampling locations within the major milksheds west of the Mississippi River, except Texas where the State Health Department collects samples for analysis by the EPA Office of Radiation Program's National Air and Radiation Environmental Laboratory in Montgomery, AL. Beginning in 1991, samples from Texas will also be analyzed by EMSL-LV. In the SMSN, samples are collected by state Food and Drug Administration (FDA) personnel by request submitted through EPA Regional Offices and are analyzed at EMSL-LV to determine radioactivity from any source.

4.2.4.2 Methods

In either network, raw milk is collected in 1-gallon (3.8-L), collapsible Cubitainers (Figure 19) and preserved with formaldehyde. Routine sampling is conducted monthly for the MSN and annually for the SMSN, or whenever local or worldwide radiation events suggest possible radiation concerns, such as the Chernobyl incident or nuclear testing by foreign nations. All samples are analyzed by high resolution gamma spectroscopy to detect gamma-emitting radionuclides. One sample per quarter from each MSN location and from two locations in each western state in the SMSN are evaluated by radiochemical analysis. These samples are analyzed for ^{3}H by liquid

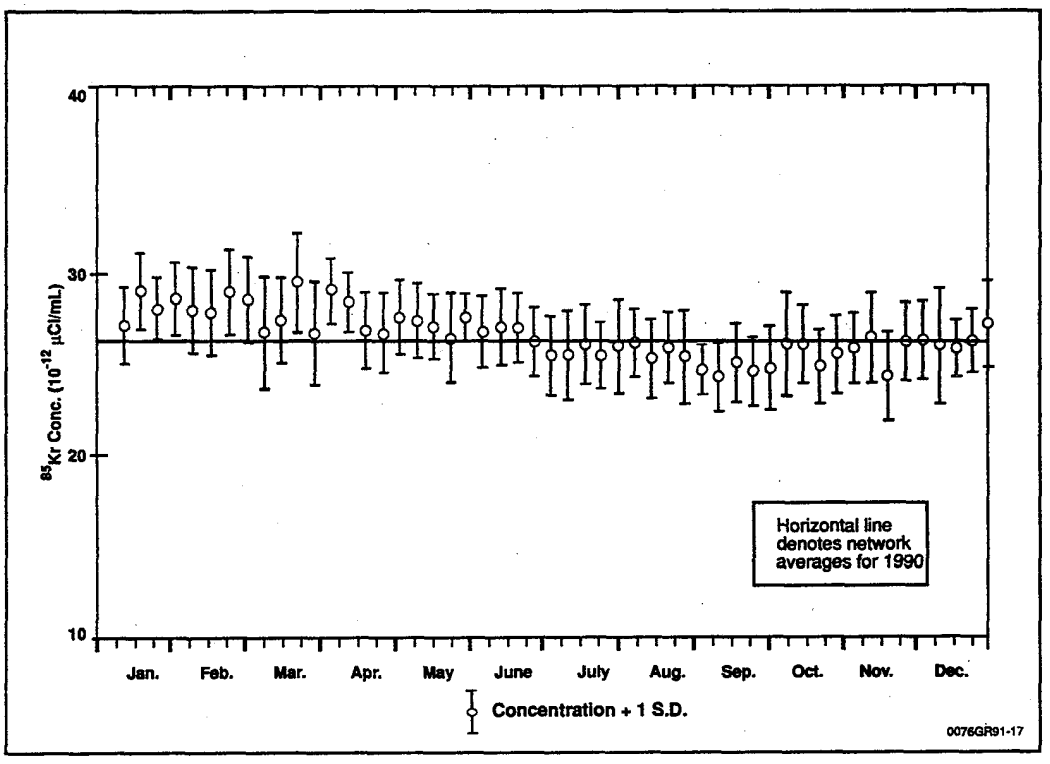

Figure 17. Network weekly average krypton concentrations in air, 1990 data.

TABLE 7. ANNUAL AVERAGE KRYPTON CONCENTRATIONS IN AIR, 1981 to 1990

SAMPLING LOCATIONS	^{85}Kr CONCENTRATIONS (10^{-12} µCi/mL)									
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
MAMMOTH LAKES CA	—	—	—	—	—	—	26	25	—	—
SHOSHONE CA	—	25	25	23	24	25	26	25	27	26
ALAMO NV	27	24	25	24	24	24	26	25	27	26
AUSTIN NV	—	24	25	23	25	25	25	25	27	26
BEATTY NV	24	25	24	23	25	26	26	26	27	26
CALIENTE NV	—	—	—	—	—	—	—	24	27	26
ELY NV	—	24	25	22	24	26	25	25	26	26
GOLDFIELD NV	—	25	24	24	24	25	25	25	26	26
INDIAN SPRINGS NV	24	24	25	22	24	26	26	25	26	27
LAS VEGAS NV	24	24	24	23	25	25	25	26	26	26
LATHROP WELLS NV	24	24	26	22	24	25	25	26	26	26
OVERTON NV	26	24	25	23	24	25	25	26	26	26
PAHRUMP NV	23	24	24	23	25	25	26	25	26	26
RACHEL NV	24	26	24	22	24	25	25	26	27	27
TONOPAH NV	25	24	25	23	25	25	26	25	27	26
CEDAR CITY UT	—	25	24	22	24	24	26	25	26	26
ST. GEORGE UT	—	24	25	23	24	24	25	26	26	27
NETWORK AVERAGE	24	24	25	23	24	25	26	25	26	26

— *No station was operational at that location during that year.*

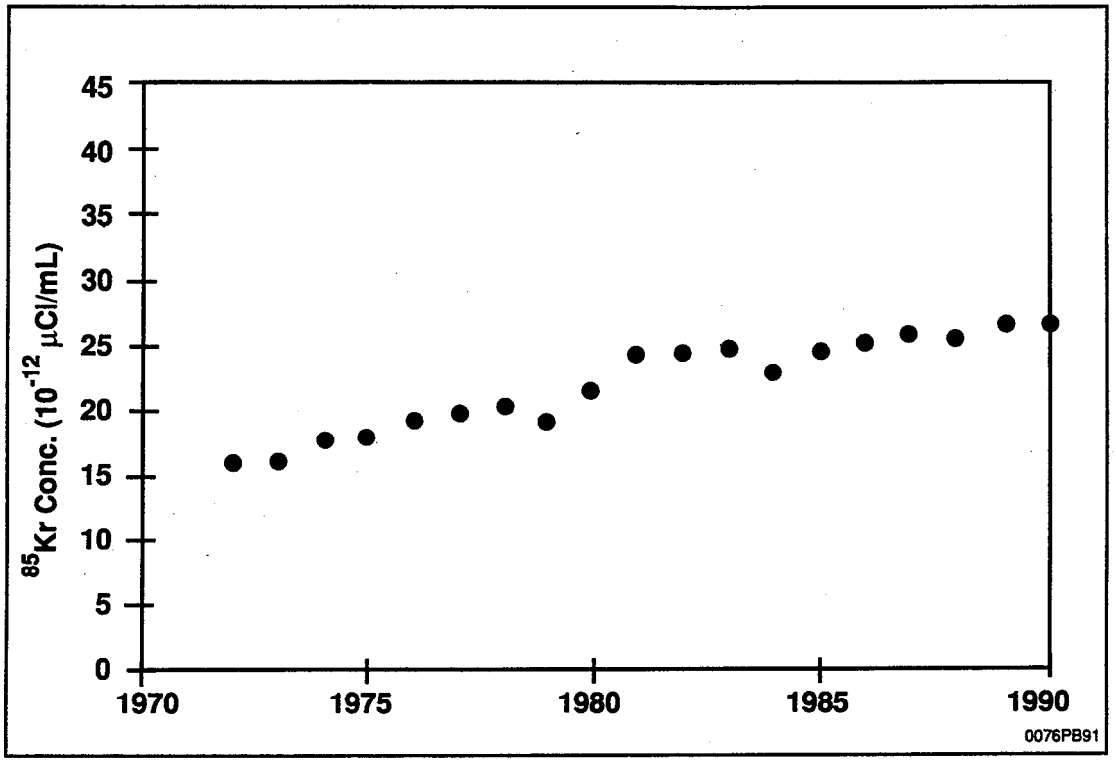

Figure 18. Annual network average krypton concentrations.

scintillation counting and for ^{89}Sr and ^{90}Sr by an ion exchange method, as outlined in Chapter 8. Figures 20 and 21 show the locations of the collection sites.

4.2.4.3 Quality Assurance/Quality Control

Quality assurance procedures consist of taking two or more samples at the same time from the same source and using standardized procedures for sample handling and analysis. In addition, randomly selected samples are rerun as blind duplicate measurements. Intercomparison and spiked samples are run in accordance with QC requirements presented in Section 6.2. Analytical results are reviewed by a health physicist for completeness and comparability. Trends are identified and potential risks to humans and the environment are determined based on the data. Data quality objectives were met for all 1990 analyses.

4.2.4.4 Results

Samples from the MSN and SMSN were analyzed for gamma emitting radionuclides. Only naturally occurring ^{40}K was detected. Selected samples were also analyzed for ^{3}H and ^{89,90}Sr. Only one sample (SMSN Boise, ID) was found to contain ^{3}H slightly above the MDC, which is well within expected statistical variation (an expected five percent false positive). Strontium-90 above the MDC was detected in two locations (Shoshone, NV, and Ivins, UT) in the MSN. Ivins, UT, had a single sample slightly above the MDC, which is consistent with an expected false positive rate of five percent. Shoshone, NV, had three out of four values slightly over the MDC. The samples from this location were collected in May through November, when the cows were on green feed. The same sets of samples were also slightly positive in the preceding year. Tables A2 and A3 (Appendix) present analytical results for the MSN and SMSN, respectively.

Seventeen locations in the SMSN were also slightly above the ^{90}Sr MDC (2×10^{-9} µCi/mL [7×10^{-2} Bq/L]). Those samples showing positive results are mainly from the midwest and south where weather patterns and precipitation have resulted in greater soil inventories of ^{89,90}Sr with resultant uptake by vegetation and transfer to dairy animals and milk. These values have decreased significantly since the early 1960s (Figure 22). In conclusion, no radioactivity directly related to current NTS activities was evident in either MSN or SMSN samples in 1990.

Data in Figure 22 were compiled through the Pasteurized Milk Network operated by the EPA's

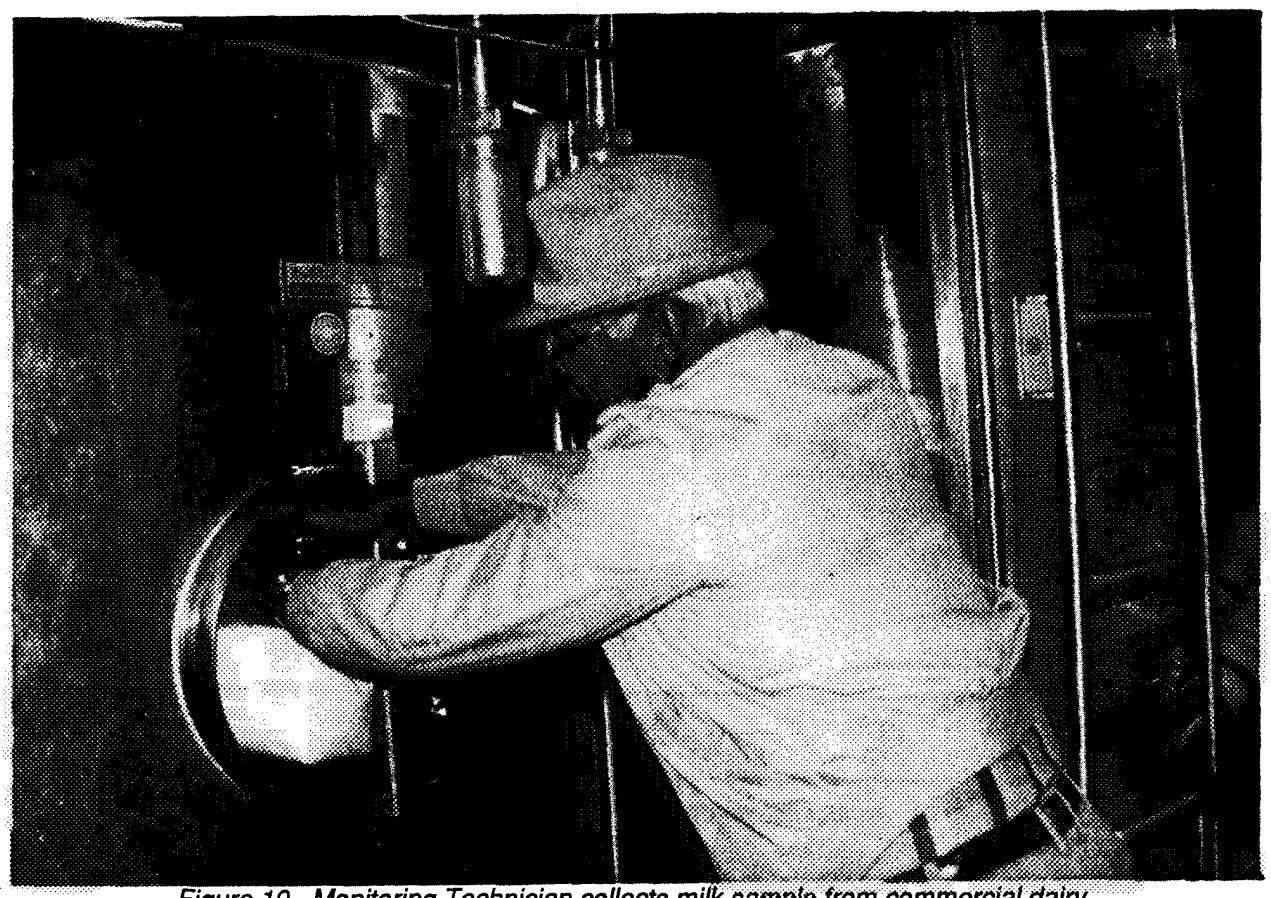

Figure 19. Monitoring Technician collects milk sample from commercial dairy.

National Air and Radiation Environmental Laboratory in Montgomery, AL (EPA 88A). Data from samples collected in the MSN and SMSN over the years indicate a comparable downward trend in levels of radioactivity.

The box-and-whisker plots (Figures A3 and A4 in the Appendix) from selected MSN locations are typical of the values found over the last ten years. While some individual ^{3}H sampling results rose above the MDC (approximately 350 x 10^{-9} µCi/mL [13Bq/L]) in response to isolated atmospheric releases, the median values remained below the MDC for tritium. Analytical results for ^{90}Sr from the same locations show fluctuations of values within expected statistical variability and medians at or below the MDC of about 2 x 10^{-9} µCi/mL (7 x 10^{-2} Bq/L) for Mesquite, NV, which supplies milk for the Las Vegas area, Pahrump, NV, and Cedar City, UT. Median values for milk from Shoshone, NV, are slightly higher. The higher values occurred during the summer grazing months, indicating the ^{90}Sr in the soil may be taken up by forage crops, probably due to soil mineral deficiencies, or may be ingested as particulates during grazing.

Plots of the SMSN data (Figures A5 and A6 in the Appendix) by area for the past ten years show the medians to be at or below the MDC, again with some samples exhibiting higher values following isolated controlled atmospheric releases or changes in feeding practices. Strontium-90 values tend to be slightly higher in the midwest area due to greater deposition of fallout during the 1960s as a result of weather patterns and precipitation. Forage in these areas take up the radionuclide and it passes through the forage-cow-milk-man food chain.

To facilitate surveillance activities, a comprehensive census of milk cows and goats has been compiled. Updated through interim survey as part of routine monitoring and by general resurvey every two years, this information is computerized and a Milk Cow Directory is published containing the number of cows and goats, the type of feed, use of the milk (marketed or consumed by the family), and the precise location of the collection source by both latitude and longitude and road/mileage directions. This survey covers all of Nevada and the counties in California, Idaho, and Utah that border Nevada.

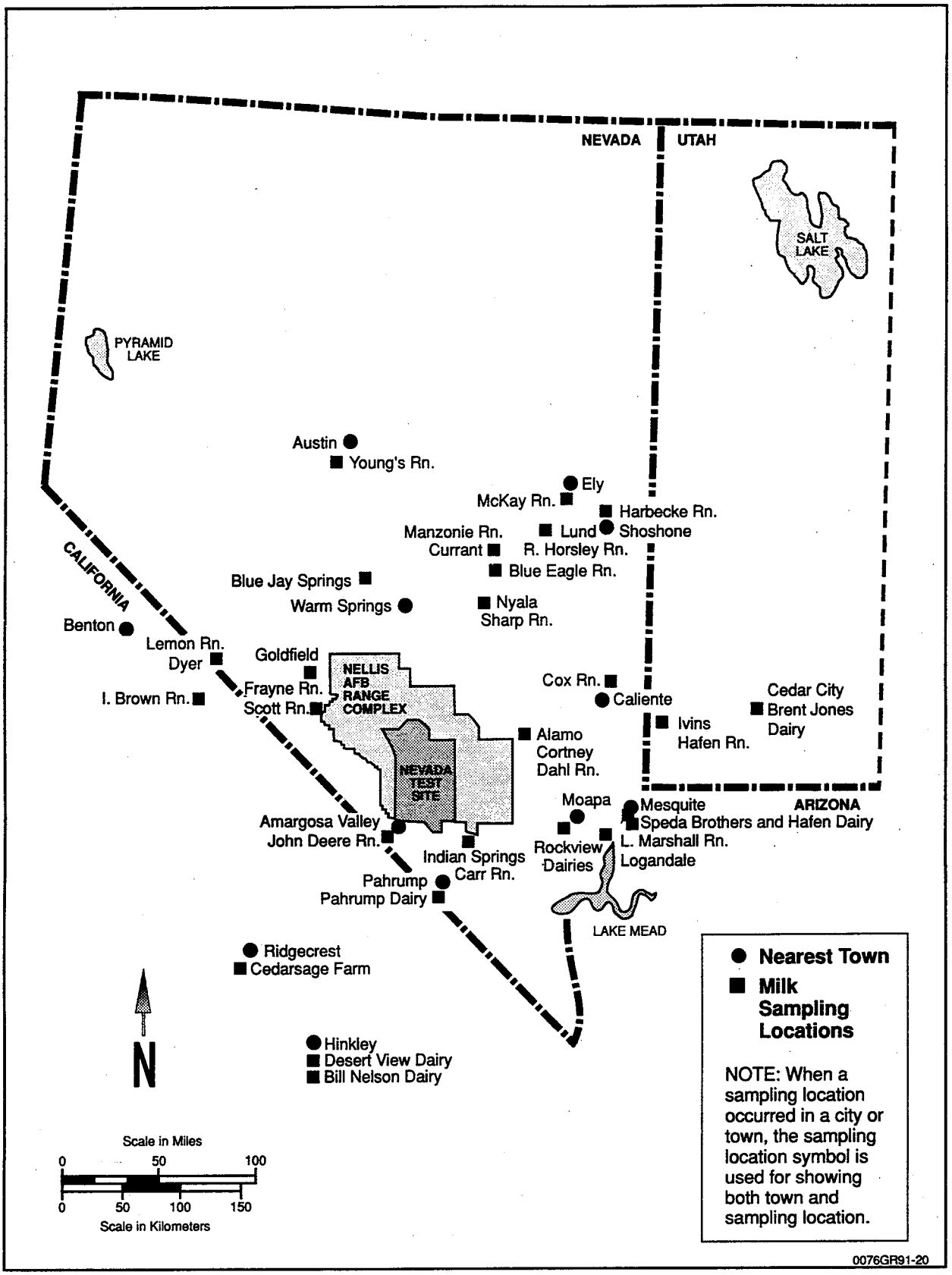

Figure 20. Milk sampling locations within 180 miles (300 km) of the Nevada Test Site.

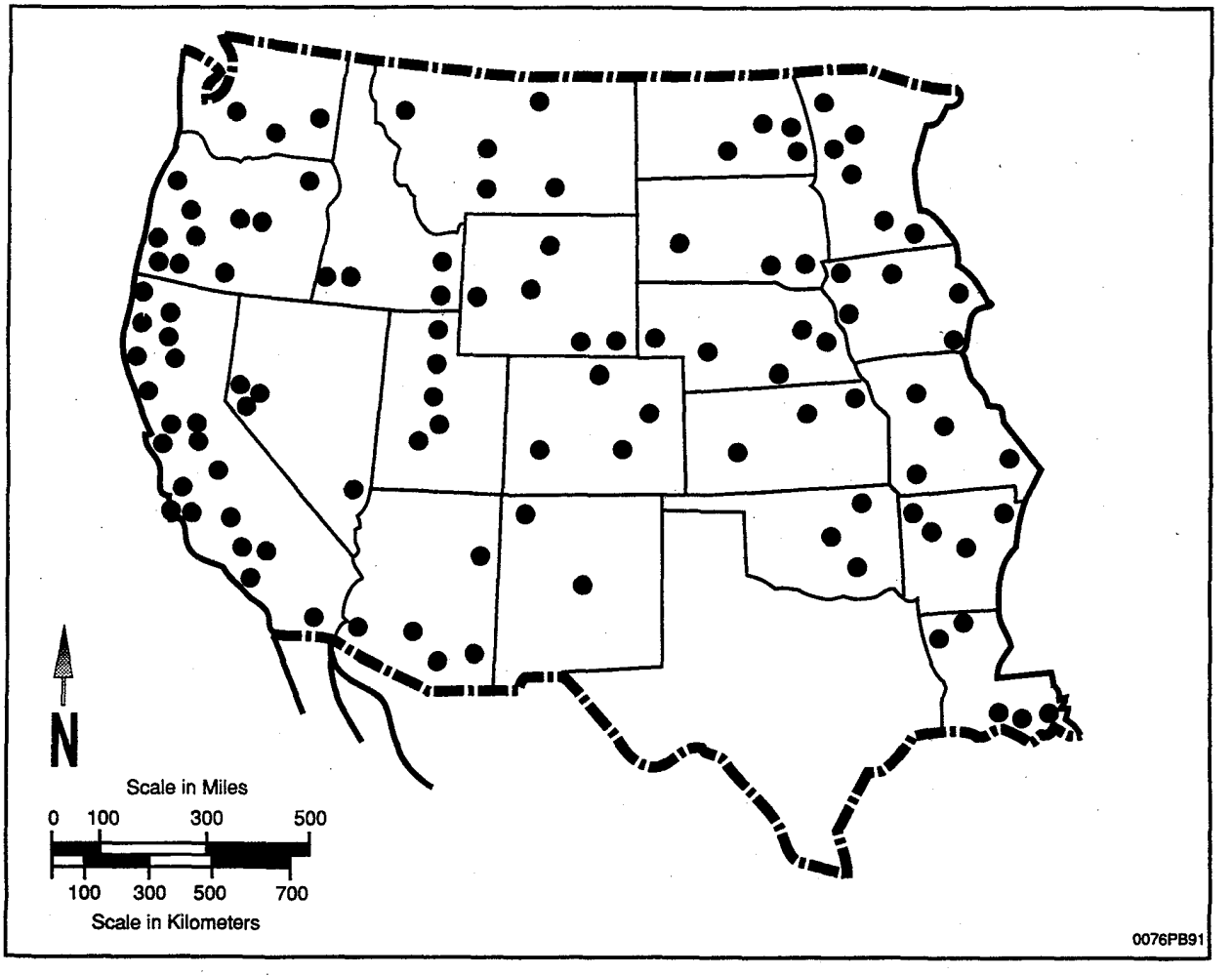

Figure 21. Standby Milk Surveillance Network stations.

4.2.5 Biomonitoring Program

D. D. Smith

The pathways for transport of radionuclides to humans include air, water, and food. Monitoring of air, water, and milk have been discussed in the previous sections. Meat from grazing animals and locally grown fruit and vegetables are food components that may be potential routes of exposure to offsite residents. Grazing animals ingest forage from large areas of ground surface and so represent a concentrating mechanism. Home garden vegetables may be a direct route of exposure for humans. Analyses of animal and vegetable samples are discussed in this section. Data for the last ten years for selected tissues are graphically displayed as box-and-whisker plots in the Appendix. Data results for 1990 were, in general, consistent with previous years and indicate no significant contribution by current NTS activities to concentrations of radionuclides found in grazing animals and vegetables.

4.2.5.1 Design and Methods

In the spring and again in the fall of each year, four cattle are purchased from commercial beef herds that graze on areas adjacent to the NTS. The animals are sacrificed and necropsied. Bone and liver samples are analyzed for ^{90}Sr and for $^{238,239+240}Pu$. Muscle, kidney, lung, liver, and thyroid are analyzed for gamma emitters; blood or kidney samples are analyzed for ^{3}H.

Once each quarter during the calendar year, a mule deer is collected from the NTS (Figure 23). Muscle, liver, lung, thyroid, and rumen contents samples are analyzed for gamma emitters and samples of muscle, liver, lung, rumen contents, and bone are analyzed for $^{238,239+240}Pu$. Bone tissue is also analyzed for ^{90}Sr and selected tissues are analyzed for ^{3}H.

For the last 33 years, during the desert bighorn sheep hunt each November and December in southern Nevada, licensed hunters have donated bone and kidney samples to EMSL-LV. The bone samples are analyzed for ^{90}Sr and $^{238,239+240}Pu$, while the kidney samples are analyzed for ^{3}H and gamma emitters. The areas from which the bighorn sheep, mule deer, and cattle were collected in 1989 and 1990 are shown in Figure 24.

Vegetables are collected annually, if possible, from home gardens in the near offsite areas or in the prevailing downwind direction. Tubers (e.g., potatoes), fruits (e.g., tomatoes, squash), and leafy vegetables (e.g., chard) are donated by local gardeners. These samples are analyzed by gamma spectrometry and for ^{3}H, ^{90}Sr, and $^{238,239+240}Pu$.

Water is extracted from the blood, kidney, and vegetable samples for ^{3}H analyses. Samples for ^{90}Sr and $^{238,239+240}Pu$ analyses are ashed prior to analysis by a contract laboratory. The analytical methods are summarized in Chapter 8.

4.2.5.2 Quality Assurance/Quality Control

Quality assurance procedures include the submission of blind duplicate tissue samples and spiked bone ash samples in each shipment to the analytical laboratory. The analytical results of these samples are discussed in Chapter 6.

4.2.5.3 Results

Bighorn Sheep — Analytical data from bones and kidneys of desert bighorn sheep collected during the late fall of 1989 are presented in Table 8. Tritium concentration in the kidneys of the 17 animals sampled did not exceed the MDC of 520 pCi/L (19.3 Bq/L) and are characteristic of values seen during the last decade (see Figure A7 in the Appendix). As shown in Figure A8 (Appendix), ^{137}Cs is a gamma emitter that is infrequently detected in sheep kidneys (three animals in 1989). The source of the ^{137}Cs is thought to be worldwide fallout. The three values detected were 0.023, 0.051, and 0.097 pCi/g wet weight (0.85, 1.9, and 3.6 Bq/kg).

Strontium and plutonium values detected in the sheep bones are similar to those reported during the 1980s (Figures A9 through A11 in the Appendix). The average ^{90}Sr concentration of 1.0 pCi/g bone ash is consistent with values reported in recent years and is comparable to values found in two other large ruminant species on and around the NTS (Figure 25).

Cattle — Tritium concentrations in the blood of the beef cattle sampled during 1990 did not exceed the MDC of 390 to 450 pCi/L (14.4 to 16.7 Bq/L). These values are similar to those reported during the last few years (Figure A12 in the Appendix). One kidney sample contained 20 ± 10 pCi/kg wet weight (0.7 ±

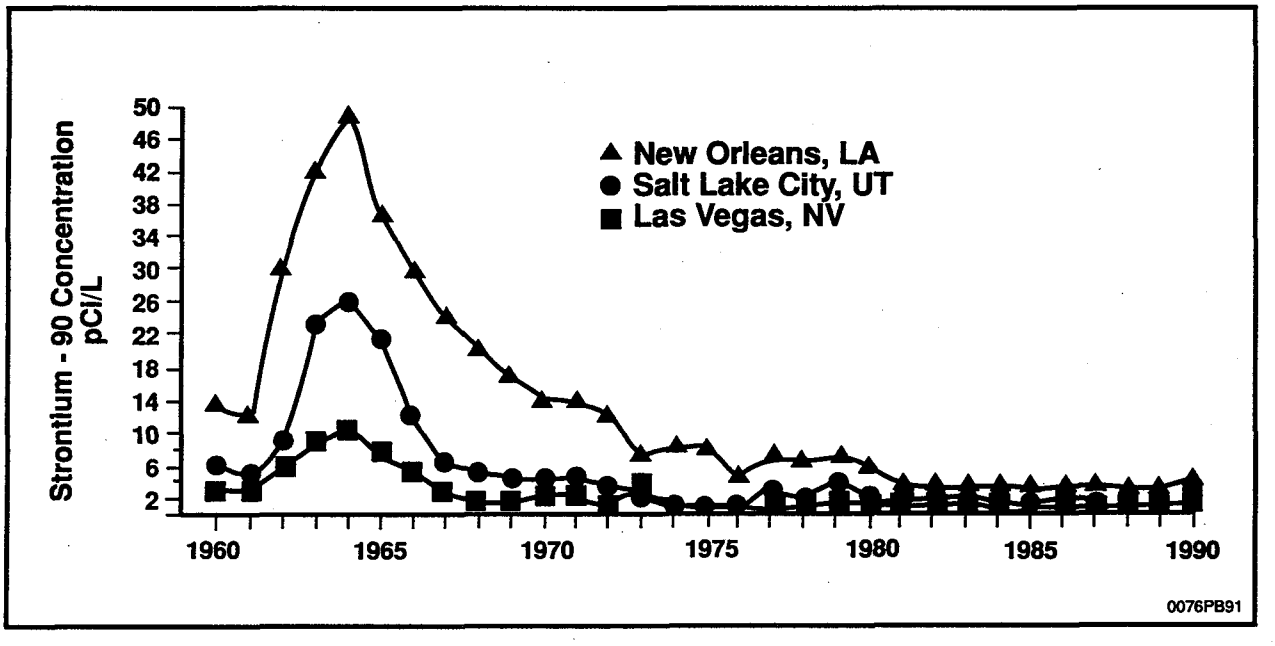

Figure 22. Strontium-90 concentrations in Pasteurized Milk Network samples.

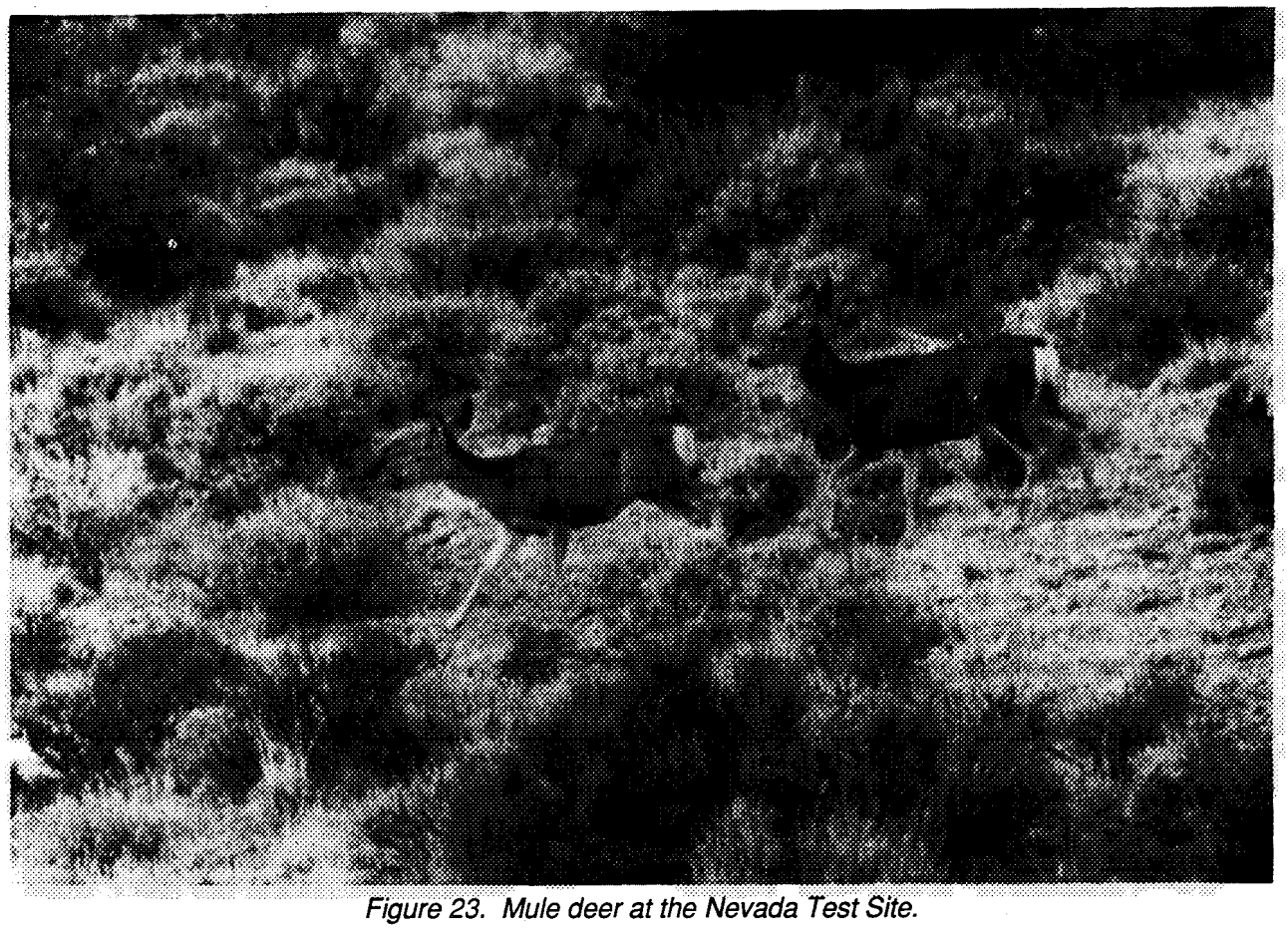

Figure 23. Mule deer at the Nevada Test Site.

0.4 Bq/kg) of ^{137}Cs. Other than naturally occurring ^{40}K, this was the only gamma emitter detected.

Strontium-90 concentrations in cattle bones ranged from 0.3 to 1.9 pCi/g of ash (0.01 to 0.07 Bq/g of ash) with an average of 1.0 pCi/g of ash (0.04 Bq/g of ash). The 1990 ^{90}Sr values are compared to those of the last ten years in a box-and-whisker plot (Figure A13 in the Appendix) and with other large ruminants in Figure 25.

Plutonium-238 values reported in cattle liver ranged from 0.002 to 0.007 pCi/g of ash (7×10^{-5} to 2.6×10^{-4} Bq/g of ash) and for bone ranged from 0.0007 to 0.008 pCi/g of ash (2.6×10^{-5} to 2.9×10^{-4} Bq/g of ash). The $^{239+240}Pu$ values in liver ranged from –0.0003 to 0.03 pCi/g of ash (-1.1×10^{-5} to 1.1×10^{-3} Bq/g of ash) and in bones ranged from –0.0009 to 0.005 pCi/g of ash (-3.3×10^{-5} to 1.9×10^{4} Bq/g of ash). These values are similar to those reported in recent years, as shown in box-and-whisker plots for the last ten years (Figures A14 through A17 in the Appendix).

Mule Deer — Tritium levels in mule deer tissues (combined muscle, kidney, blood, liver, and urine) for the last ten years are depicted in Figure A18 in the Appendix. It should be noted that the plotted concentrations are on a logarithmic scale and show the wide range in concentration reported in recent years. The high values observed in past years were in deer that drank from contaminated drainage ponds in Area 12 of the NTS. None of the deer sampled in 1990 drank from these ponds and ^{3}H concentrations were below the MDC of 520 to 570 pCi/L (19.2 to 21.1 Bq/L).

The kidney from one animal contained a ^{137}Cs concentration of 38 ± 14 pCi/kg (0.14 ± 0.52 Bq/kg). The only other gamma emitter detected, other than the naturally occurring ^{40}K, was the naturally occurring ^{7}Be, with a maximum concentration of 460 ± 200 pCi/kg (17 ± 7.4 Bq/kg). A ^{137}Cs concentration of 17 ± 9 pCi/kg (0.63 ± 0.3 Bq/kg) was found in the rumen contents of one deer.

Strontium-90 values reported in NTS deer bones ranged from 0.5 pCi/g of ash (0.019 Bq/g of ash) to 1.0 pCi/g of ash (0.038 Bq/g of ash). As shown in Figure 25, the average concentration was 0.8 pC/g of ash (0.03 Bq/g of ash). Plutonium-238 values in

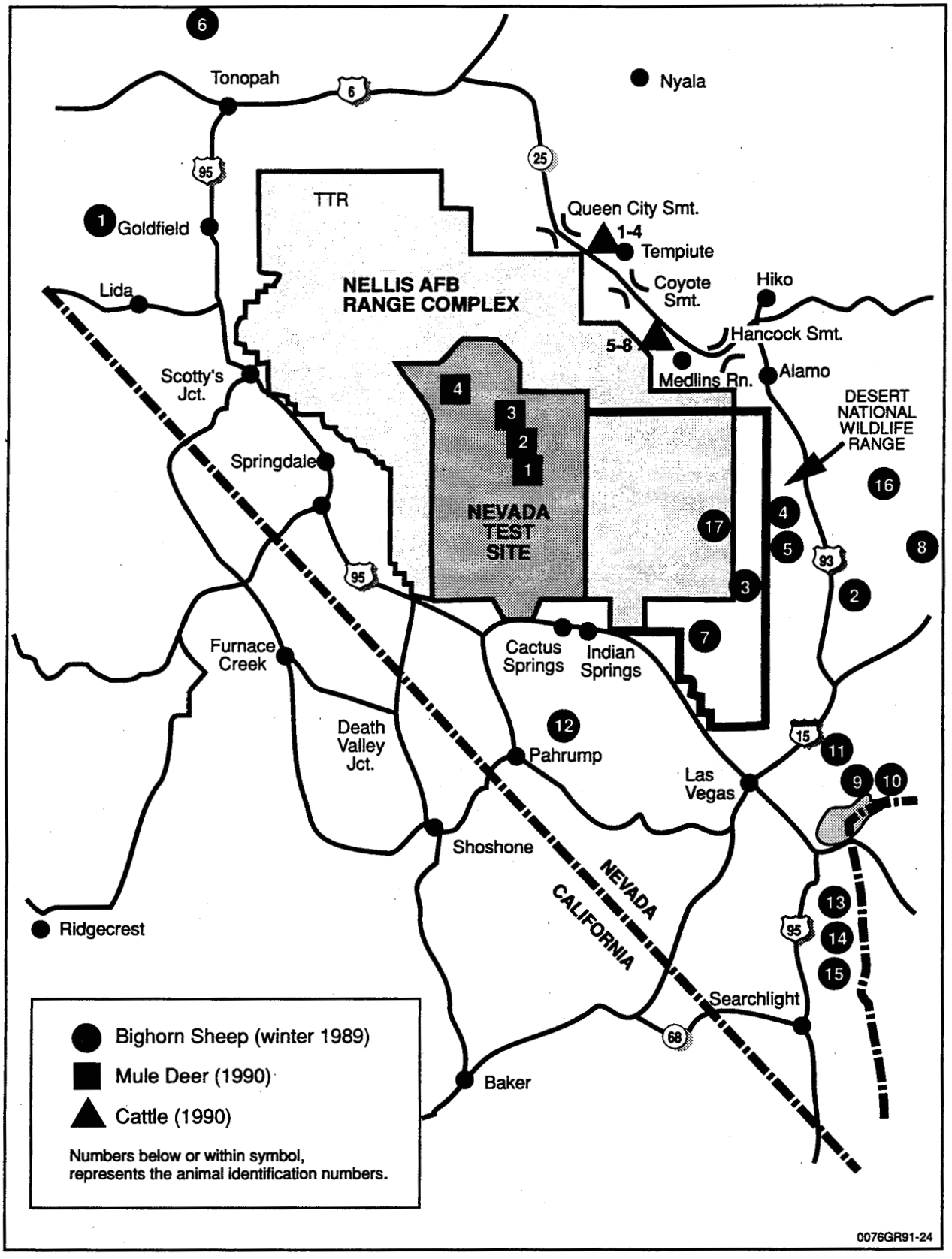

Figure 24. Collection sites for animal samples.

TABLE 8. RADIONUCLIDE CONCENTRATIONS IN DESERT BIGHORN SHEEP SAMPLES — 1989

BIGHORN SHEEP (COLLECTED WINTER 1989)	% ASH	BONE ^{90}Sr CONC. ± 1 S.D. (pCi/g ASH)[b]	BONE ^{238}Pu CONC. ± 1 S.D. (10^{-3}pCi/g ASH)[b]	BONE $^{239+240}Pu$ CONC. ± 1 S.D. (10^{-3}pCi/g ASH)[b]	KIDNEY[a] ^{3}H CONC. ± 1 S.D. (pCi/L)[c]	KIDNEY ^{137}Cs CONC. ± 1 S.D. (pCi/g)[b]
1	42	1.7 ± 0.04	−3.4 ± 1.7	1.7 ± 1.6	130 ± 160[d]	0.051 ± 0.014
2	26	1.1 ± 0.04	8.9 ± 4.2	0.4 ± 1.2[d]	330 ± 100	-
3	40	1.1 ± 0.03	8.6 ± 3.3	0.5 ± 0.9[d]	20 ± 100[d]	-
4	32	1.3 ± 0.04	3.7 ± 5.6[d]	0.2 ± 0.8[d]	350 ± 100	-
5	31	1.4 ± 0.04	−0.9 ± 2.9[d]	0.2 ± 0.8[d]	20 ± 300[d]	-
6	26	1.4 ± 0.03	3.2 ± 3.6[d]	0.2 ± 0.9[d]	180 ± 100	-
7	26	0.7 ± 0.02	3.0 ± 3.9[d]	1.2 ± 1.5[d]	−120 ± 155[d]	-
8	28	1.4 ± 0.04	3.3 ± 3.7[d]	−0.3 ± 1.0[d]	95 ± 100[d]	-
9	25	0.3 ± 0.02	1.3 ± 3.1[d]	0.7 ± 1.1[d]	−120 ± 100[d]	-
10	31	0.4 ± 0.02	7.7 ± 4.2	−0.9 ± 0.8[d]	−75 ± 100[d]	-
11	33	1.0 ± 0.03	1.0 ± 3.6[d]	−1.0 ± 0.8[d]	−30 ± 155[d]	0.023 ± 0.007
12	24	1.2 ± 0.04	3.7 ± 3.3	0.7 ± 1.0[d]	100 ± 160[d]	-
13	21	0.5 ± 0.02	0.8 ± 3.3	0.3 ± 1.1[d]	70 ± 160[d]	-
14	22	0.5 ± 0.02	−2.0 ± 4.3[d]	1.2 ± 1.5	−230 ± 155[d]	-
15	30	0.4 ± 0.02	Lost in Chemistry	Lost in Chemistry	350 ± 150	-
16	22	1.9 ± 0.04	Lost in Chemistry	Lost in Chemistry	210 ± 100	-
17	Bone Sample not collected				−140 ± 155[d]	0.097 ± 0.032
Median	29.5	1.1	3.25	0.35	95	0.051
Range	21 to 42	0.3 to 1.7	−3.4 to 8.9	−1.0 to 1.7	−230 to 350	0.023 to 0.097

[a] *Aqueous portion of kidney tissue.*
[b] *To convert pCi/g to Bq/kg, divide concentration by 0.027.*
[c] *To convert pCi/L to Bq/L, divide concentration by 27.*
[d] *Counting error exceeds reported activity.*

mule deer bones ranged from 0.0029 to 0.008 pCi/g of ash (0.0001 to 0.0003 Bq/g of ash) and $^{239+240}Pu$ values ranged from −0.0003 to 0.0004 pCi/g of ash (-1.1×10^{-5} to 1.5×10^{-5} Bq/g of ash). None of the $^{239+240}Pu$ values exceeded the one-sigma counting error, indicating values are not significantly greater than the MDC in a statistical sense.

Two liver samples were lost prior to analysis completion and only one ^{238}Pu value exceeded the one sigma counting error. This was 0.004 ± 0.003 pCi/g of ash ($1.5 \times 10^{-4} \pm 1.1 \times 10^{-4}$ Bq/g of ash). These values are also consistent with those observed in recent years.

Vegetables — During the summer of 1990, samples of vegetable produce were collected from offsite farms in Nevada and Utah. Refrigeration failure resulted in the loss of all samples except for the root crops. These included beets from Rachel, NV, and St. George, UT; carrots from Enterprise, UT; and potatoes from Hiko, NV. Other than naturally occurring ^{40}K, there were no detectable gamma emitters and none of the samples had a ^{3}H, ^{90}Sr, or ^{238}Pu concentration that exceeded the MDC. One sample, table beets from St. George, UT, had a detectable $^{239+240}Pu$ concentration of 0.007 ± 0.005 pCi/g of ash ($2.6 \times 10^{-4} \pm 1.9 \times 10^{-4}$ Bq/g of ash). This was probably due to incomplete washing of the soil from the sample.

Data results exhibit no direct correlation with current NTS activities. Annual vegetable crops did not contain any radionuclides above the MDC, with the exceptions of naturally occurring ^{40}K and $^{239+240}Pu$, which was in soil adhering to a root crop. None of the mule deer sampled this year had been contaminated by drinking from containment ponds. Results for all animal species were generally similar to those obtained in previous years.

4.2.6 Thermoluminescent Dosimetry Network

B. B. Dicey

The primary method of measuring external ambient gamma radiation exposures is the TLD. Since 1987, environmental and personnel monitoring for ambient gamma exposures has been accomplished using the Panasonic TLD system as shown in Figure 26. This system provides greater sensitivity, precision, and (for TLDs used to monitor offsite residents)

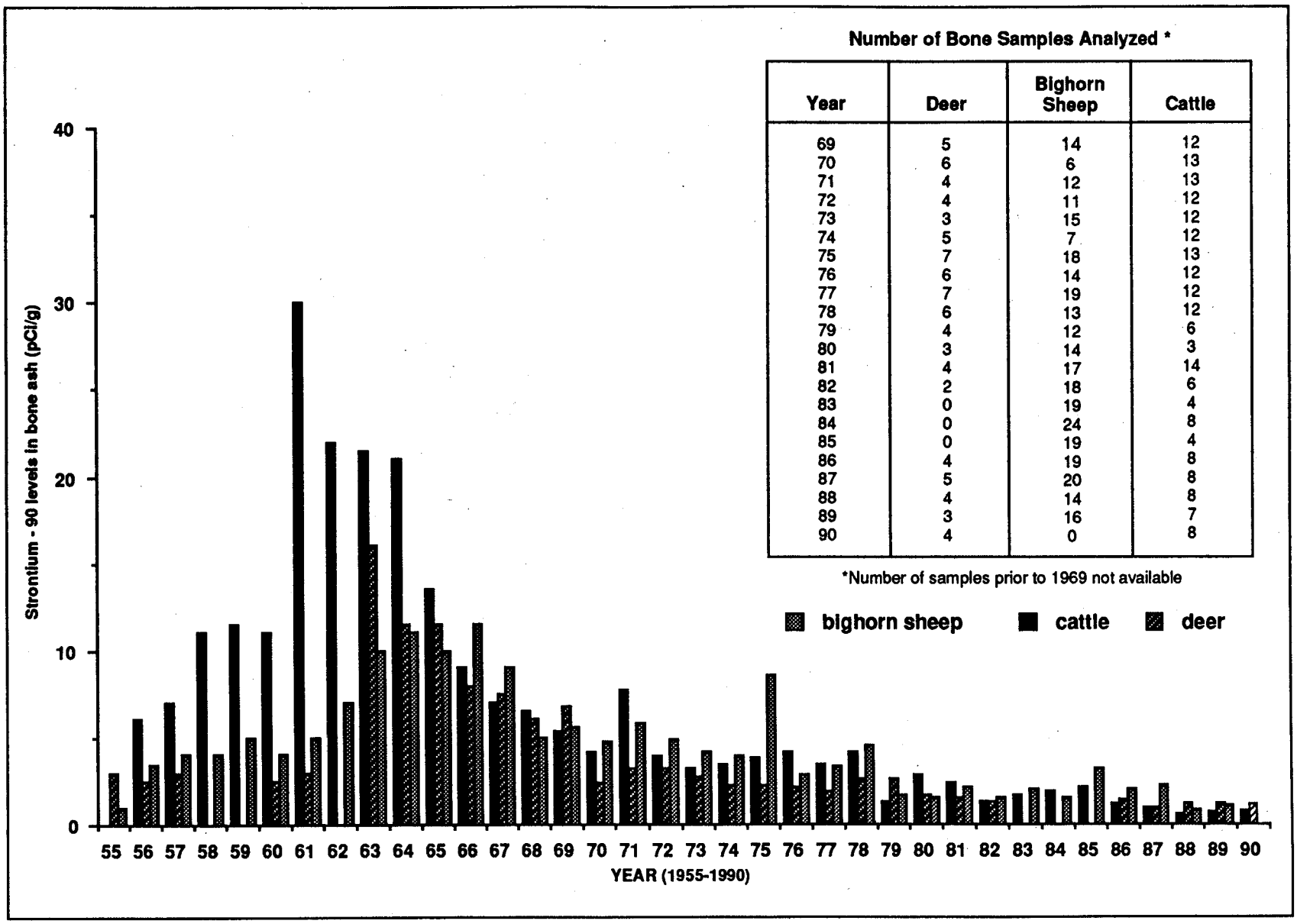

Figure 25. Average ^{90}Sr Concentrations in Animal Bone Ash.

tissue equivalence than is possible using film or other TLD systems. This facilitates correlation of individual measured exposures with the absorbed biological dose equivalent. Results for 1990 indicate no exposure directly attributable to current NTS activities.

4.2.6.1 Network Design

The TLD network is designed primarily to measure total ambient gamma exposures at fixed locations. A secondary function of the network is the measurement of exposures to a smaller number of specific individuals living within and outside estimated fallout zones from past nuclear tests at the NTS (offsite residents). Measuring environmental ambient gamma exposures at fixed locations provides a reproducible index that can be easily correlated to the maximum exposure an individual would have received by being continuously present at that location. Measurement of exposures to specific individuals involves multiple uncontrollable variables commonly associated with any personnel monitoring program. However, monitoring of individuals provides an estimate of individual exposures that help confirm the validity of correlating fixed-site ambient gamma measurements to projected individual exposures.

A network of environmental stations and monitored personnel has been established in locations encircling the NTS. Monitoring locations are shown in Figure 27. This arrangement facilitates estimation of average background exposures and prompt detection of any increase due to NTS activities.

Monitoring of offsite personnel is accomplished with the Panasonic UD-802 dosimeter. This dosimeter contains two elements of $Li_2B_4O_7$:Cu and two of $CaSO_4$:Tm phosphors. The four elements are behind 14-, 300-, 300-, and 1,000-mg/cm^2 filtration, respectively. Monitoring of offsite environmental stations is accomplished with the Panasonic UD-814 dosimeter. This dosimeter contains a single element of $Li_2B_4O_7$:Cu and three replicate $CaSO_4$:Tm elements. The first element is filtered by 14 mg/cm^2 of plastic and the remaining three are filtered by 1,000 mg/cm^2 of plastic+lead. The three replicate phosphors are used to provide improved statistics and extended response range.

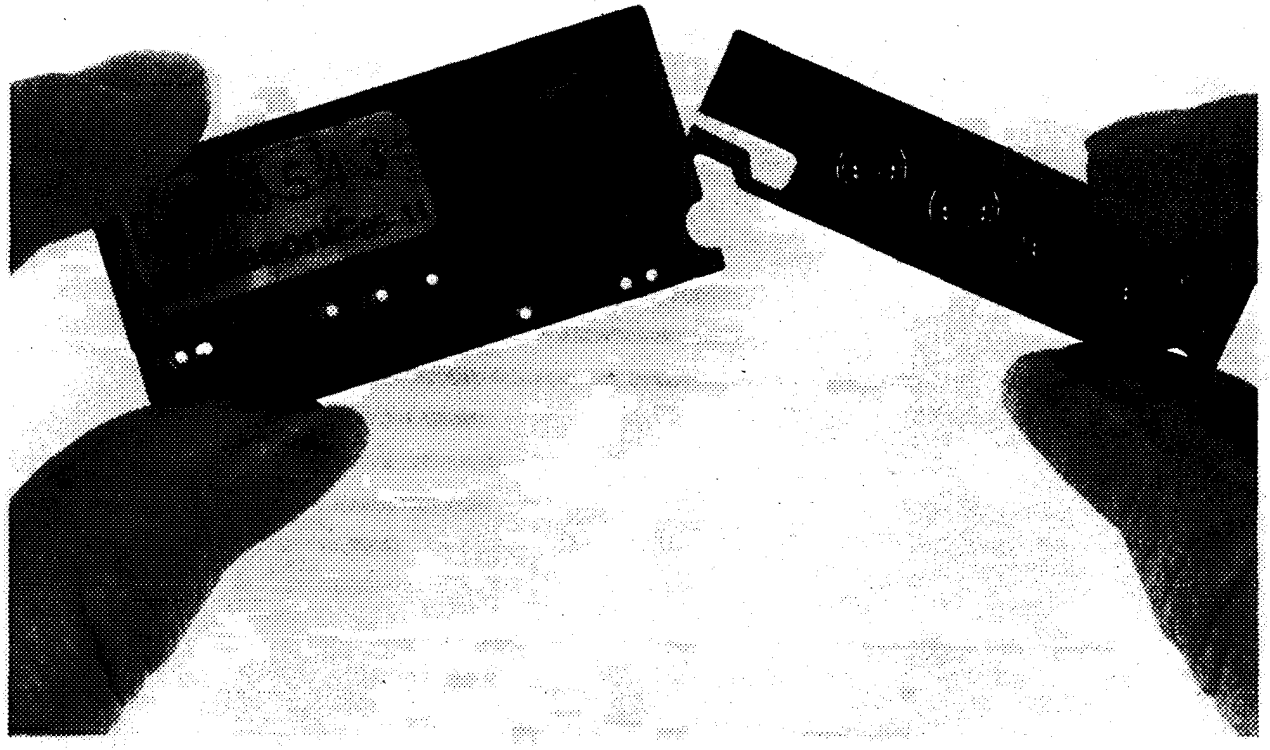

Figure 26. Construction of a typical Panasonic dosimeter.

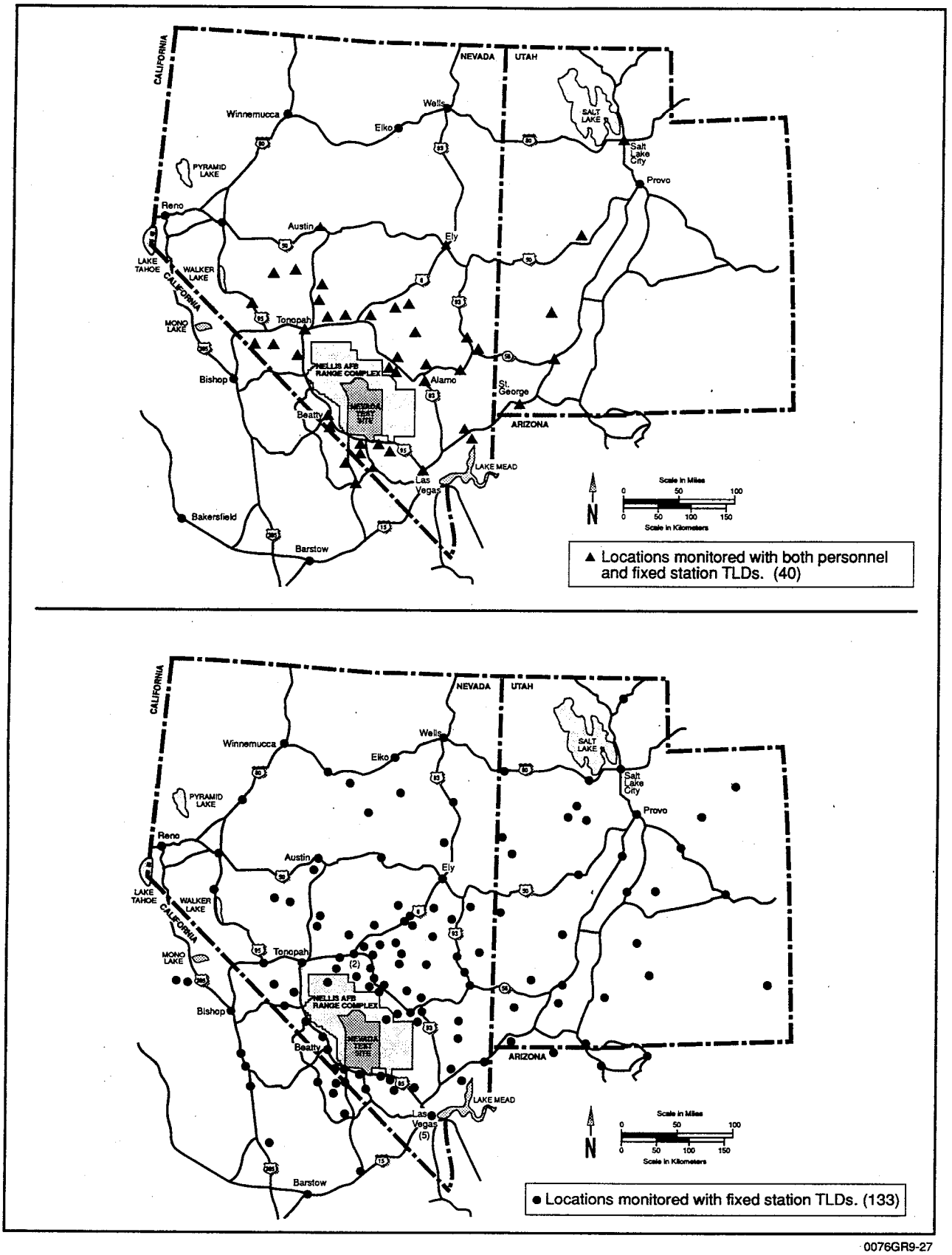

Figure 27. Locations monitored with thermoluminscent dosimeters.

4.2.6.2 Quality Assurance/Quality Control

The TLD program for monitoring of exposures to individuals is fully accredited by DOE's Laboratory Accreditation Program (DOELAP). Environmental monitoring with TLDs is conducted in accordance with the recommendations of American National Standards Institute (ANSI) Standard N545-1975, (ANSI75) and U.S. Nuclear Regulatory Commission Regulatory Guide 4.13 (NRC77).

Each field-deployed TLD is processed together with transit and unirradiated background controls and with irradiated reference correction factor (RCF) TLDs. Irradiated RCF TLDs are subjected to a known radiation exposure equivalent to a nominal absorbed dose of 200 mrem. A ^{137}Cs source having a calibrated output traceable to the National Institute of Standards and Technology (NIST) is used. All exposures are verified by simultaneous exposure to a precision ionization chamber. Calibration of the ionization chamber is also NIST traceable.

Performance and calibration of the TLD readers is verified by a series of daily QC checks as well as semiannual system calibration. System calibration verifies that the readers are linear in response over the range of 2 to 10,000 mR. Blind performance testing conducted as part of the DOELAP accreditation process verified system linearity over the range of 30 to 500,000 mR for x-rays, gamma photons, and mixtures.

4.2.6.3 Monitoring Results — Offsite Personnel

During 1990, a total of 71 individuals living in areas surrounding the NTS were provided with personnel TLDs. All personnel dosimeters are cross-referenced to associated fixed reference background TLDs. Associated reference background TLDs are fixed environmental monitoring positions located in the general vicinity of each individual's place of residence. Frequently the associated reference background is the local CMS.

The TLDs used to monitor individuals are sensitive to beta, gamma, neutron, and x-radiations. The TLDs used to monitor fixed reference background locations are designed to be sensitive only to gamma and x-radiations. Because fixed environmental TLDs are sensitive only to x- and gamma radiation, personnel TLDs are routinely evaluated for only these two radiation types. Exposures of this type are numerically equivalent to absorbed dose. Raw data for all personnel and environmental TLDs are stored in a form that permits detailed evaluation for other radiation types (beta and/or neutron), if needed. The existing dose conversion algorithm could be used for this purpose with only minimal modification. Specifically, evaluation for potential neutron exposure using TLDs would require detailed knowledge of the energy of neutrons to which the TLD was exposed.

TLDs used to monitor individuals are provided in holders designed to be worn on the front of an individual's body, between the neck and the waist. When worn in this manner, the TLD may be used to estimate ambient gamma and x-radiation exposure and to characterize the absorbed radiation dose an individual wearing the dosimeter received. Figure 28 illustrates a typical personnel TLD holder as it would be worn by a monitored individual. TLDs issued to individuals are deployed and collected on a nominal monthly schedule.

Of the 71 individuals monitored, 20 showed zero detectable exposure above that measured at the associated reference background location. Measurable variations from reference background ranged from 3.7 to 175.3 mrem in one year. When expressed as a fraction of reference background, exposures to monitored individuals ranged from 0.71 to 4.0 times background, with a median of 1.2. First and third quartiles were 1.0 and 1.75, respectively. Within the first through third quartiles, the average was 1.3 $\pm$ 0.22, where 0.22 equals one standard deviation. From this, using a 2 S.D. test, it can be concluded with 95 percent confidence that monitored individuals receiving from 0.88 to 1.72 times the associated reference background exposure in one year did not vary from associated reference background levels. Individuals receiving less than the first quartile had exposures which could not be distinguished from reference background.

Of those individuals receiving apparent exposures greater than the third quartile when compared to associated reference background levels, one (individual #358 in Beatty, NV) was determined by investigation to represent an exposure to the badge but not to the individual. In this case, the individual, a worker at the Nevada Low Level Waste Site, was triple badged: one badge each from EPA, his employer, and the Nevada Low Level Waste Site. Except for the EPA dosimeter, none of the dosimeters provided to this individual showed any detectable exposure above background. Detailed review of dosimeter processing and the exposure history of

the TLD involved did not support an explanation of dosimeter or reader malfunction. Therefore, it was concluded that the exposure recorded represented an exposure to the dosimeter but not to the individual. The remaining ten dosimeters issued to this individual in 1990 showed exposures ranging from 3.1 to 12 mrem, with an average of 8.4 ± 2.9 mrem. Average reference background exposure during the same period was 8.0 ± 1.8 mR.

A review of associated reference background exposure measurements for the remaining individuals showing apparent exposure ratios greater than the third quartile also failed to support an explanation that the individuals' exposures were due to environmental radiation exposure related to current NTS activities. Individual investigations are being conducted in each of these cases in an attempt to determine other factor(s) that may have resulted in the reported exposures. In no case did any individual or cumulative exposure exceed regulatory or ALARA investigation limits.

Table A4 (Appendix) lists the results of offsite personnel TLD monitoring for 1990. Figure A19 (Appendix) summarizes the TLD monitoring results for offsite residents living in California, Nevada, and Utah. There was no statistically significant difference between the states in the recorded means and the ranges were similar. Figure 29 illustrates the distribution of exposures measured for offsite residents.

The net exposure to any individual is determined by comparing the results of each dosimeter issued to that individual with the results obtained from dosimeters located at the associated reference background location established for that individual. Reference background dosimeters measure ambient gamma radiation exposure. Any associated reference background dosimeter reading that varies by greater than a statistically determined amount (± 2 standard deviations) from the historical mean for that location is not used in calculating net exposures to individuals because of the possibility that this variation could represent an anomaly or a contribution due to NTS activities. Also, reference background readings containing less than three data elements are not included in the calculation. This situation could arise in the event one of the two dosimeters included in a fixed environmental station deployment was damaged or otherwise unreadable.

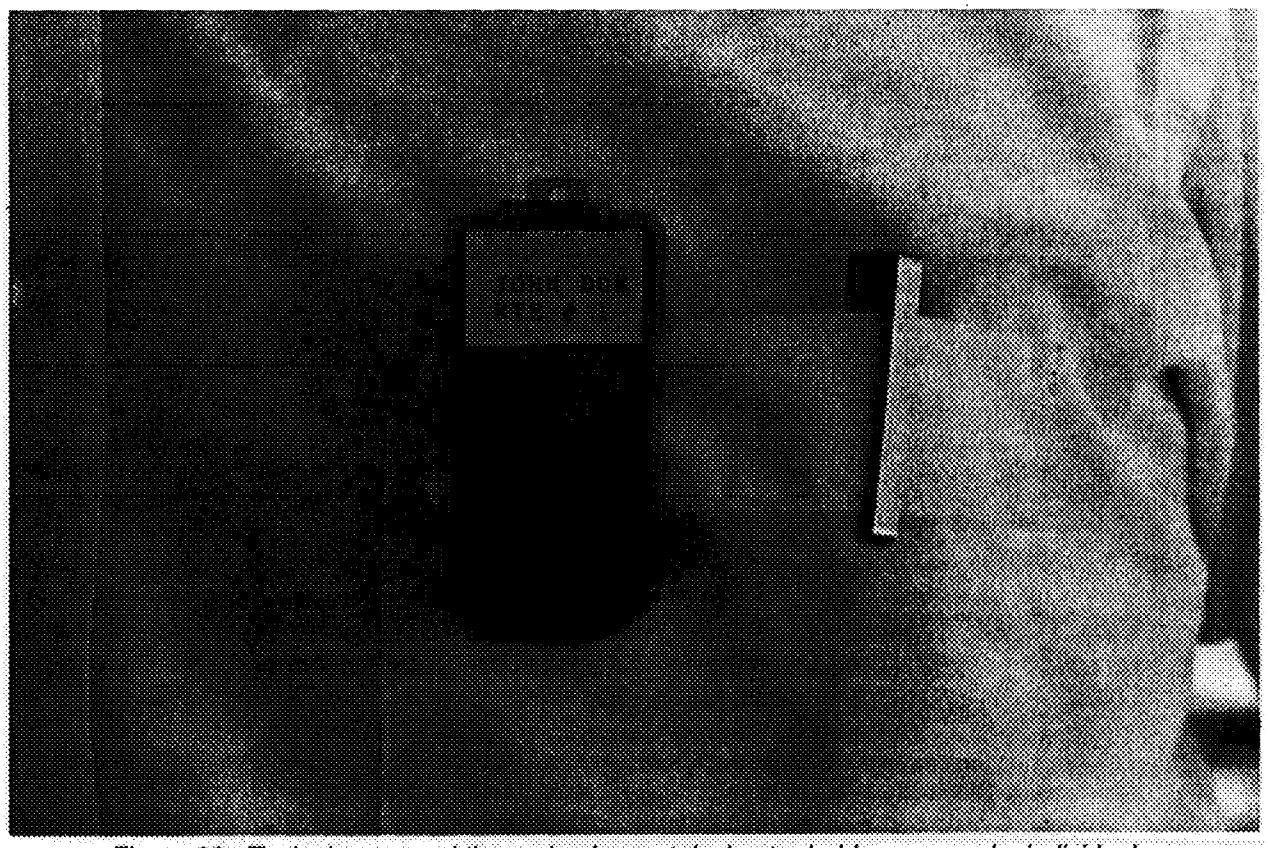

Figure 28. Typical personnel thermoluminscent dosimeter holder as worn by individuals.

4.2.6.4 *Monitoring Results — Offsite Stations*

During 1990, a total of 134 offsite stations were monitored to determine background ambient gamma radiation levels. Each station has a custom-designed holder that can hold from one to four Panasonic TLDs. Normal operations involve packaging two TLDs in a heat-sealed bag to provide protection from the elements and placing the dosimeter packet into the fixed station holder. Figure 30 illustrates a typical fixed environmental TLD monitoring station. Fixed environmental monitoring TLDs are normally deployed for a period of approximately three months (one calendar quarter).

The annual adjusted ambient gamma exposure (mR in one year) was calculated by multiplying the median daily rate for each station by 365.25. A review of the measurement periods shows that few stations were monitored for exactly 365 days. However, when the results of a "nominal" 365 day year are compared with the results obtained by multiplying the average mR/day by the actual number of days, calculational differences are less than 1 mR/year. This is considered to be an insignificant discrepancy.

Annual exposures measured at fixed environmental stations ranged from 18 to 391 mR, with a median of 73 mR. Table A5 (Appendix) details the results obtained at each of the fixed environmental stations monitored by TLDs during 1990. Figure A20 (Appendix) summarizes the results obtained from measurements of natural background ambient gamma radiation levels at fixed environmental station locations.

During 1990, the maximum net annual exposure at an offsite station was measured to be 391 mR. This exposure, at Warm Springs #2, was determined to be due to elevated levels of naturally occurring radioactive material present in a stream adjacent to the monitoring location. Radiation levels measured in a nearby parking lot (Warm Springs #1) indicated an exposure of 139 mR in one year at that location. A detailed evaluation of the Warm Springs #1 and Warm Springs #2 monitoring locations was included in the 1989 Annual Report (EPA90).

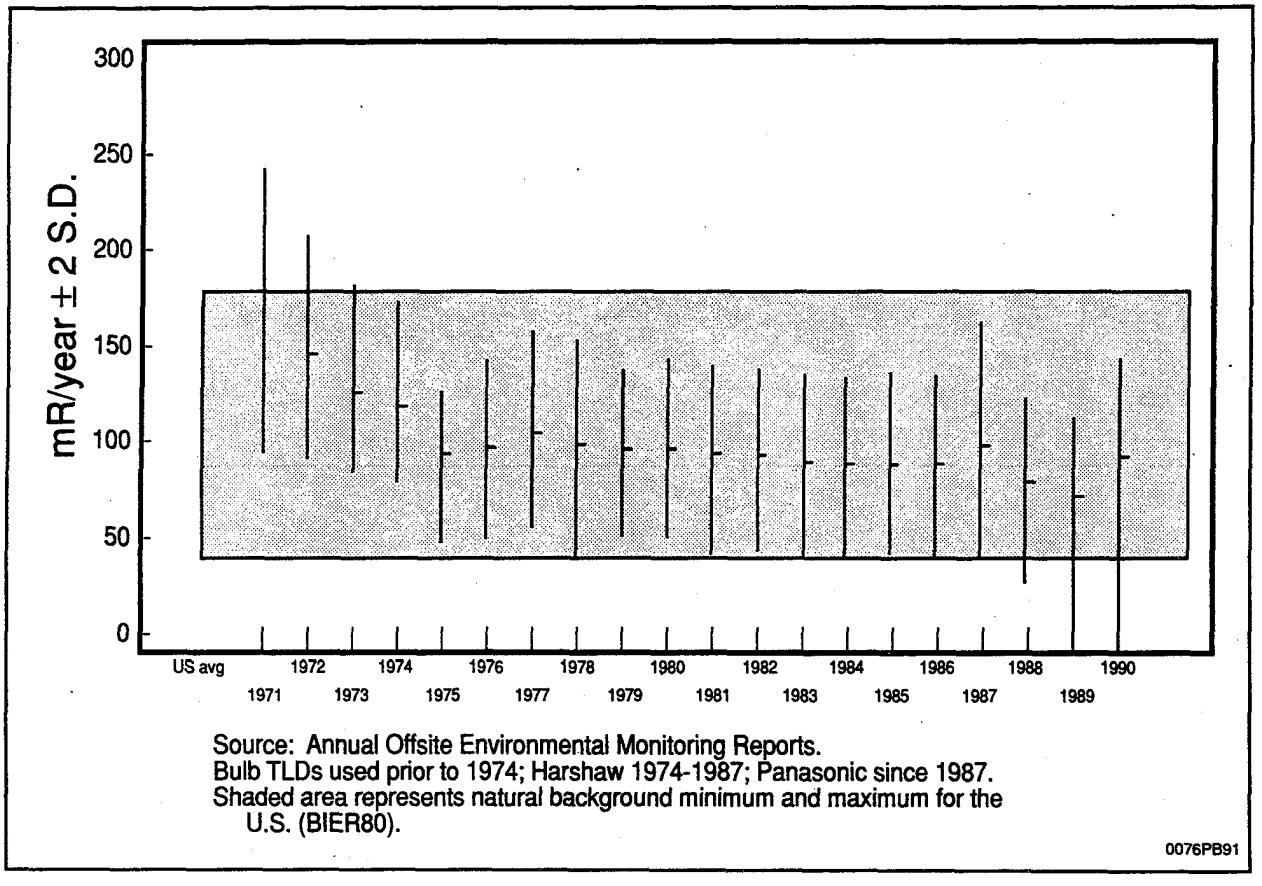

Figure 29. Summary of ambient gamma exposure of offsite residents — 1990.

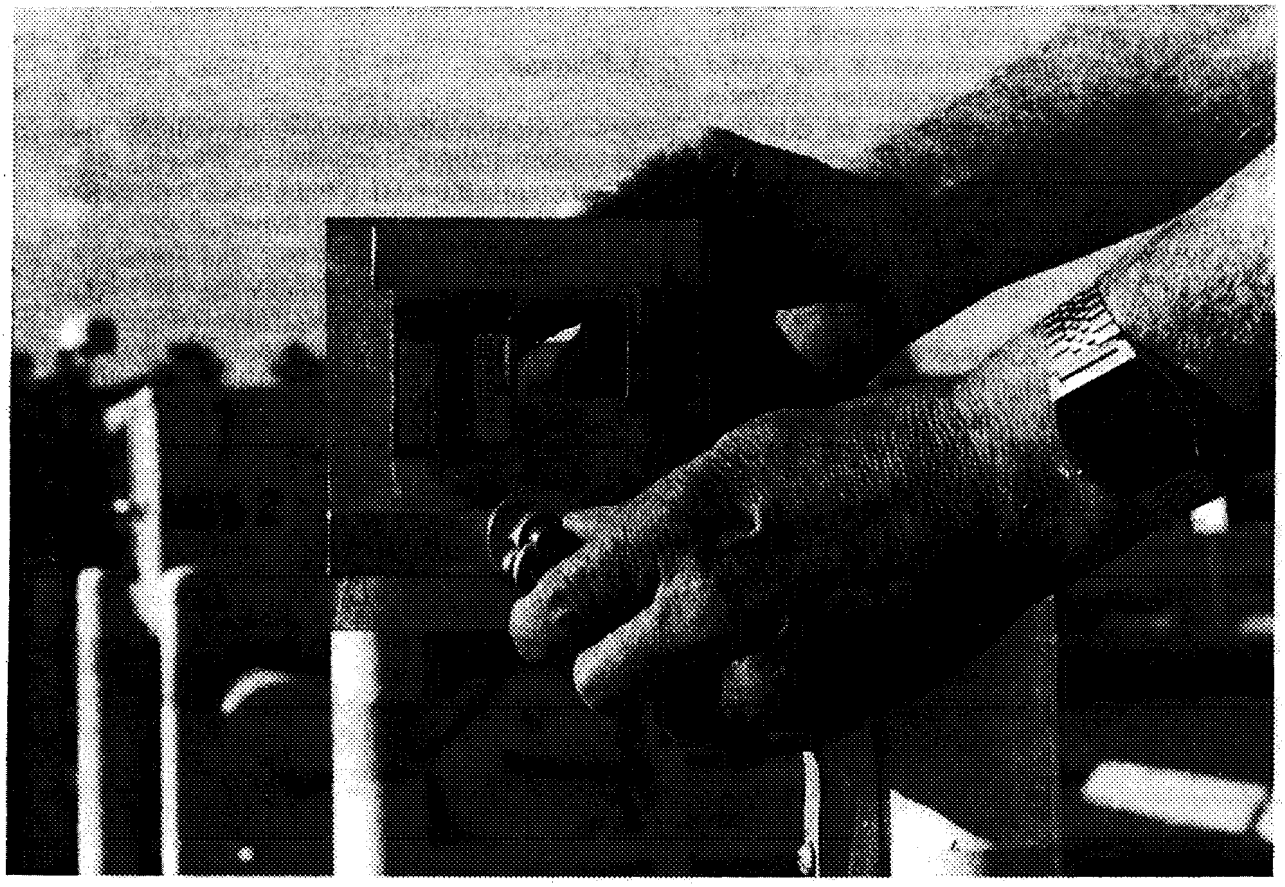

Figure 30. Typical fixed environmental thermoluminscent dosimeter monitoring station.

The primary function of fixed environmental station TLDs is to characterize ambient (natural background) gamma and x-radiation fields. The practice of subtracting reference background readings from fixed environmental station results is valid only to evaluate whether a single measurement varies by a significant amount from the historical record for that location.

Data collected in 1990 to study the impact of self-annealing during the hottest portion of the year were inconclusive. In this study, "test" TLDs were deployed at indoor locations at the Las Vegas airport and the Las Vegas U.S. Department of the Interior office. Initial results appear to indicate a reduction in indoor exposure levels at the two locations, possibly due to structural shielding.

Because of the great range in the results, an average for all offsite station TLDs is not an appropriate tool for estimating individual exposures. Environmental ambient radiation levels vary markedly with natural radioactivity in the soil, altitude, and other factors. If environmental TLD data are to be used in estimating the background radiation exposure of an individual, results obtained at the fixed environmental station closest to that individual would be the most appropriate reference point. Figure 31 presents the frequency distribution of exposures to offsite residents and to fixed environmental stations. The results indicate no significant exposures related to current NTS activities.

4.2.6.5 Discussion

When calculated TLD exposures were compared with results obtained from collocated PICs, a uniform underresponse of TLD vs. PIC was noted as depicted in Figure 32. This difference could be attributable primarily to the differing energy response of the two systems. The PICs have a greater sensitivity to lower energy gamma radiation than the TLDs and hence will normally record a higher apparent exposure rate than do the TLDs. This difference could be attributable to four primary factors:

- The PIC measures ionization in air (the Roentgen) while the TLD measures energy deposited in matter (the rad). Results of the two methods are not adjusted to account for this difference.

- The PIC is an exposure rate measuring device, sampling every five seconds. The TLD, an integrating dosimeter, is analyzed approximately once each quarter. Some reduction in TLD results may be due to normal fading. Studies by Panasonic have shown this loss to be minimal over the sampling period used. A six-month fade study was completed during 1990. The study confirmed that fading is negligible.

- PICs are more sensitive to lower energy gamma radiation than are TLDs. A review of the manufacturers' specifications for the PIC and TLD systems shows their responses to be close to linear above approximately 80 and above approximately 150 keV, respectively; and

- PICs are calibrated by the manufacturer against ^{60}Co, while the TLDs are calibrated using ^{137}Cs. No adjustment is made to account for the differing energies at which the two systems are calibrated.

4.2.7 Pressurized Ion Chamber Network

C. A. Fontana

The PIC network measures ambient gamma radiation exposure rates. In addition to the 28 PICs deployed around the NTS, there are ten Bureau of Land Management (BLM) Remote Automatic Weather Stations (RAWS) PICs. All showed no unexplained deviations from background levels during 1990. The maximum annual average exposure rate of 160 mR/yr (4.2×10^{-5} C/kg-yr) was at Austin, NV; the minimum of 50 mR/yr (1.3×10^{-5} C/kg-yr) was at Las Vegas, NV. These values were within the United States background maximum and minimum values (BEIR80). The 1990 data were consistent with previous years' trends, and no prolonged unexplained deviations from background occurred during the year.

4.2.7.1 Network Design

The purpose of the PIC network is to measure ambient gamma radiation exposure rates. These

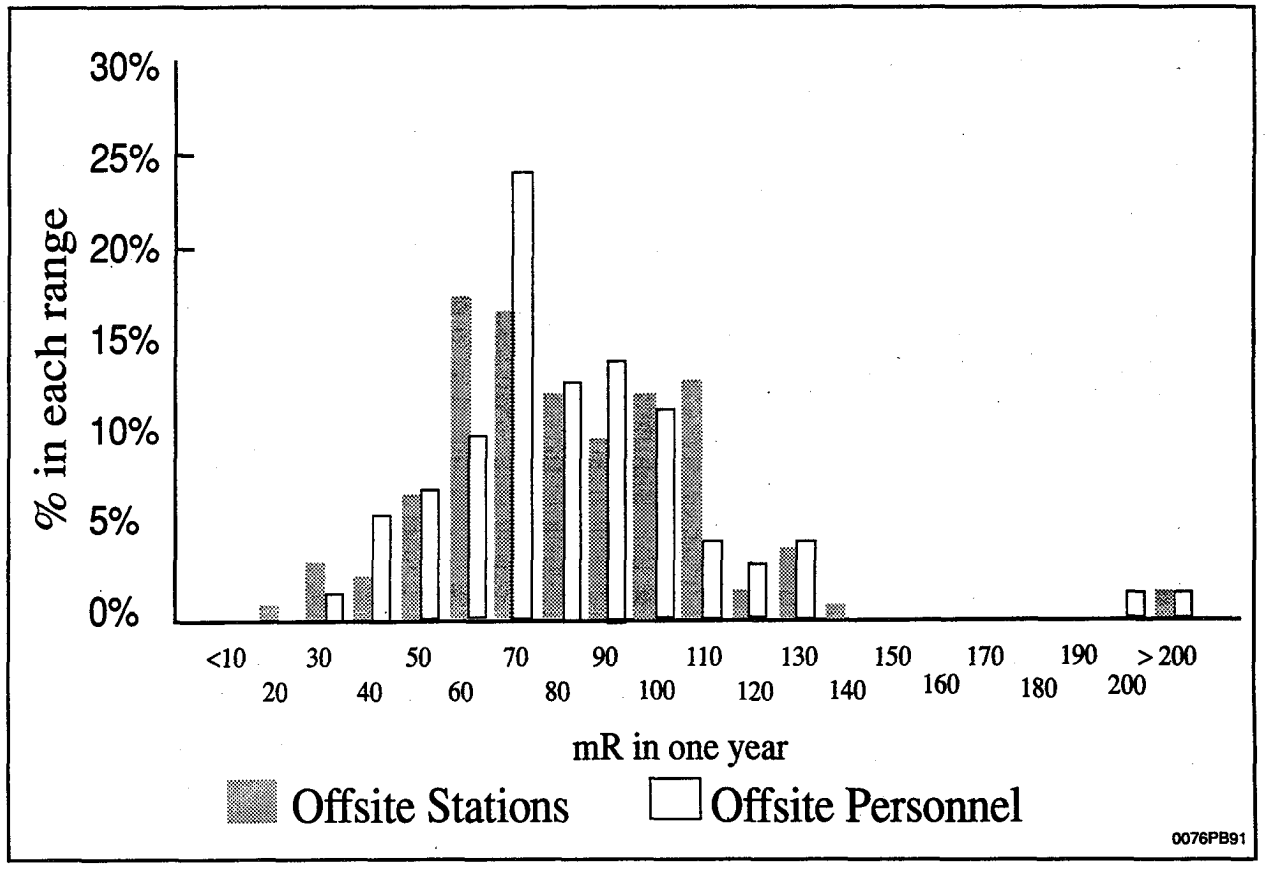

Figure 31. Frequency distribution analysis, fixed station, and personnel thermoluminscent dosimeters— 1990.

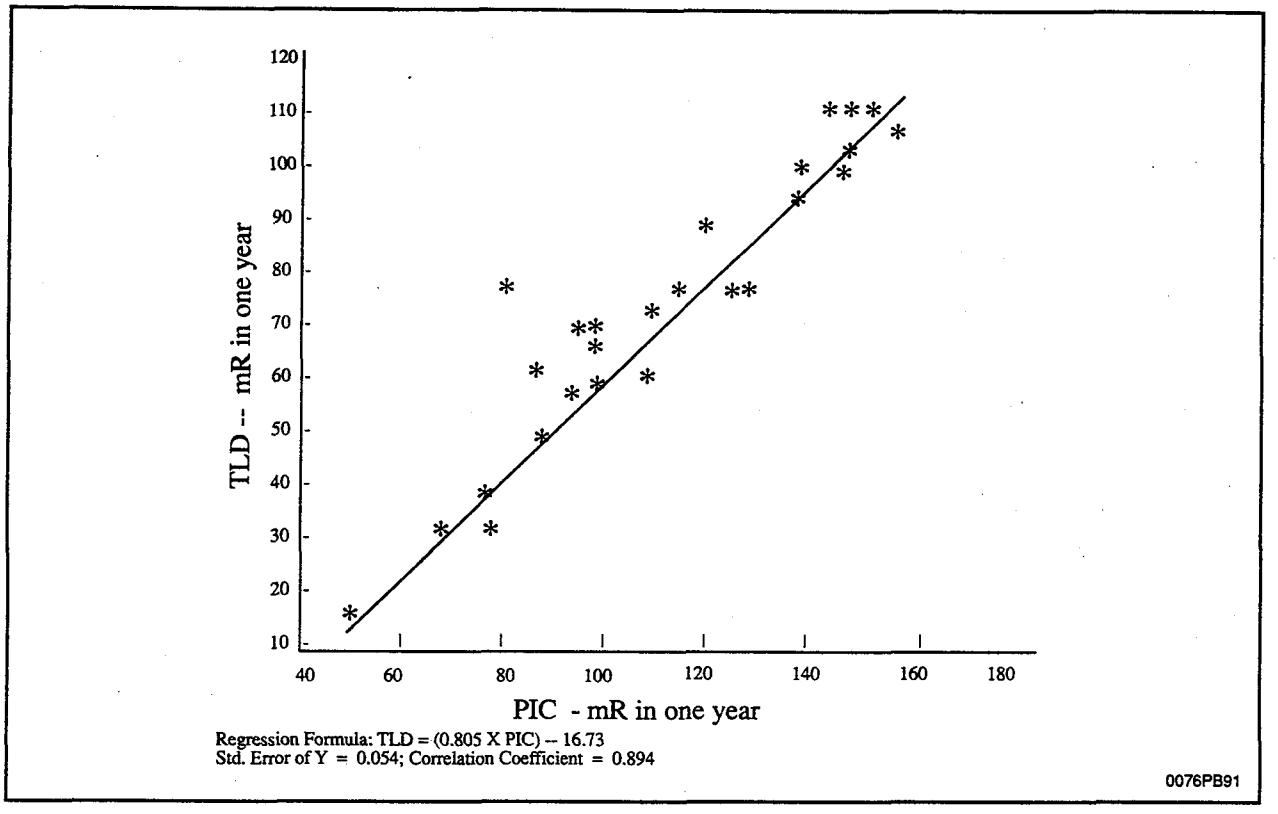

Figure 32. Comparison of thermoluminscent dosimeter results to pressurized ion chamber results — 1990.

rates vary with altitude (cosmic radiation) and natural radioactivity in the soil (terrestrial radiation). The PIC is a spherical shell filled with argon gas to a pressure 25 times that of atmospheric. In the center of the chamber is a spherical electrode with a charge opposite to the outer shell. When gamma radiation penetrates the sphere, ionization of the gas occurs and the ions are collected by the center electrode. The current generated is measured, and the intensity of the radiation field is determined from the magnitude of this current.

There are 28 PICs deployed in nearby communities around the NTS. Of these, 19 are at CMSs described in Section 5. Figure 33 shows PIC locations in California, Nevada, and Utah. The ten RAWS are utilized to expand the coverage of the PIC network. The data are exclusively acquired via satellite transmission. The locations of all PICs are shown in Figure 34.

4.2.7.2 Methods

All data are transmitted via the Geostationary Operational Environmental Satellite (GOES). In addition to telemetry retrieval, all of the data except for the RAWS locations are also recorded on magnetic media and strip charts for hard copy backup. In the event of an accidental release of radioactivity from the NTS, signals transmitted through the GOES system would provide instantaneous data from all affected PIC locations. Figure 35 shows PIC equipment setup in the field.

Data are displayed in μR/hr (microroentgens per hour, which is equivalent to 2.6×10^{-10} C/kg-hr) on a digital readout display at each location for easy access by the public. The roentgen is a measure of exposure to x- or gamma radiation. A microroentgen is one millionth of a roentgen. For example, one chest x-ray results in an exposure of 20,000 to 40,000 μR (5.2×10^{-6} to 10×10^{-6} C/kg). Computer analysis of the data is conducted weekly at EMSL-LV. Trends are noted as part of routine QA procedures. Source checks are conducted weekly and data are plotted for comparison to previous weeks.

4.2.7.3 Quality Assurance/Quality Control

The external ambient gamma exposure rate measurements made by the PICs are validated by calibrating annually. Weekly checks are made using

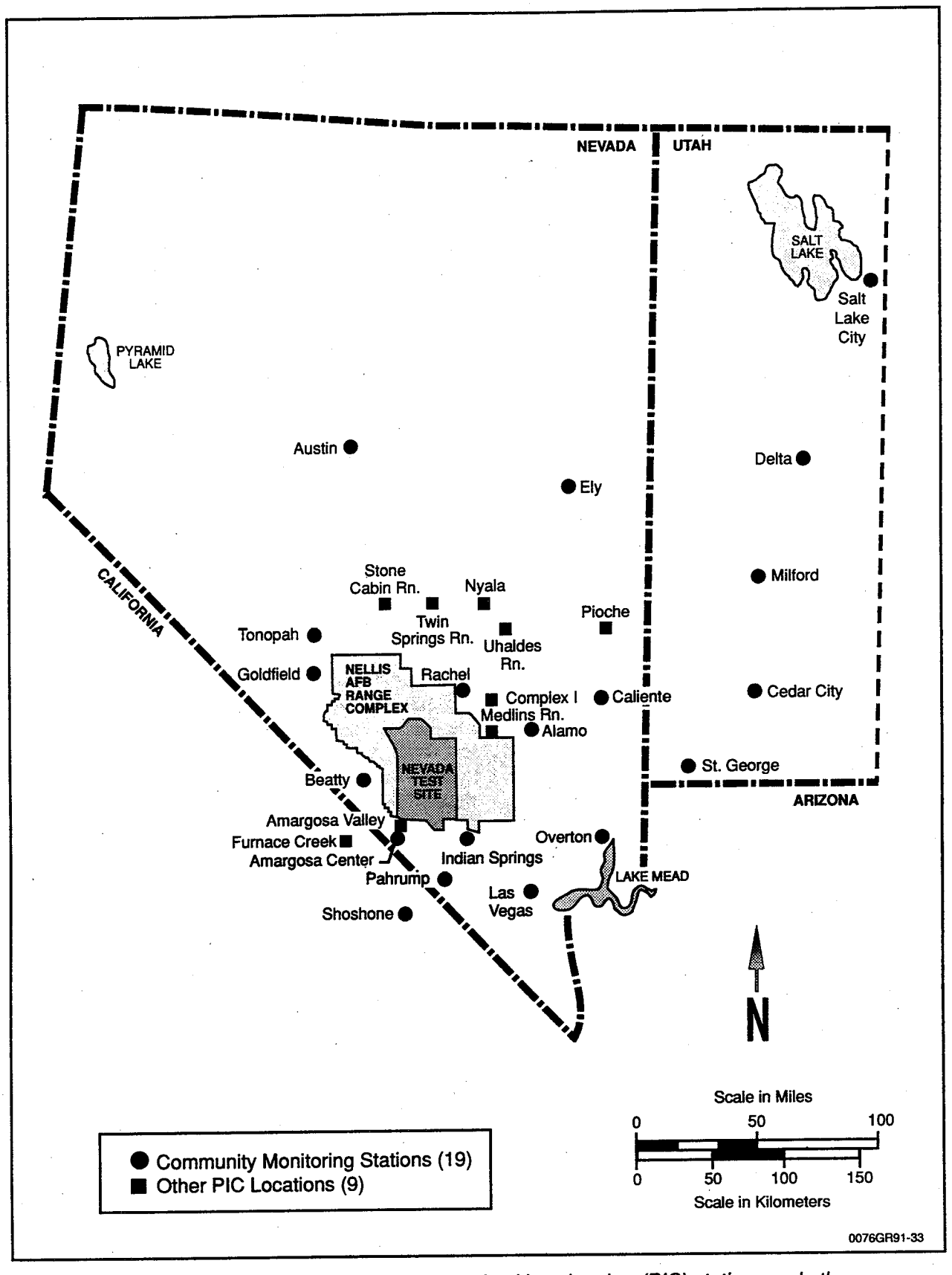

Figure 33. Community monitoring pressurized ion chamber (PIC) stations and other PIC station locations — 1990.

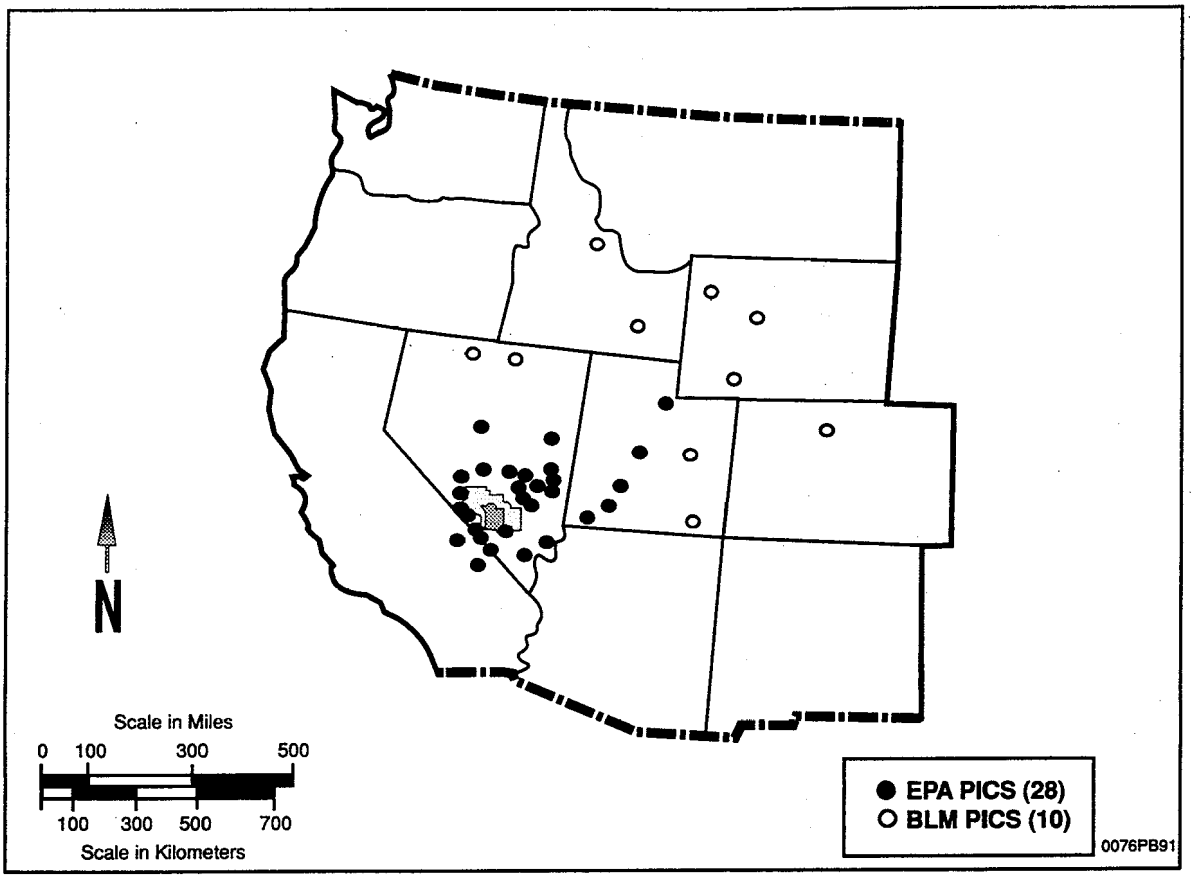

Figure 34. Pressurized Ion Chamber Network, including remote automatic weather stations operated by the Bureau of Land Managment.

radioactive sources of known activity and control charts are maintained. Data and calibration checks are evaluated to detect trends or anomalies.

4.2.7.4 Results

Data for 1990 are displayed in Table 9 as the average μR/hr and annual mR/yr (mR/yr is equivalent to 2.6 x 10^{-7} C/kg-yr) for each station. Figure 36 shows box-and-whisker plots (described in Section 6.4.1) for each location in μR/hr as compared to the maximum and minimum United States background (BEIR80). The averages of the 28 PICs operated for the EPA, DOE, and DRI varied from 50 mR/yr (1.3 x 10^{-5} C/kg-yr) at Las Vegas, NV, to 160 mR/yr (4.2 x 10^{-5} C/kg-yr) at Austin, NV. The U.S. background maximum and minimum values of the combined terrestrial and cosmic components of environmental gamma radiation exposure rates represent the highest and lowest values, respectively. Figure A21 (Appendix) shows historical annual μR/hr PIC exposure rates from all stations, except the BLM RAWS locations. The 1990 PIC data are consistent with previous years' trends and within U.S. background maximum and minimum values. No prolonged unexplained deviations from background levels occurred.

4.2.8 Internal Exposure Monitoring

A. A. Mullen

No internal exposure above applicable regulatory limits was detected in either occupationally exposed individuals or members of the general public who participated in the Offsite Internal Dosimetry Program at EMSL-LV. During 1990, a total of 1,500 gamma spectra from whole-body counting of 236 individuals were obtained, of whom 120 were participants in the Internal Dosimetry Program.

Internal exposure is caused by ingested or inhaled radionuclides that remain in the body either temporarily or for longer times because of storage in tissues. At EMSL-LV, two methods are used to detect body burdens: whole-body counting and urinalysis.

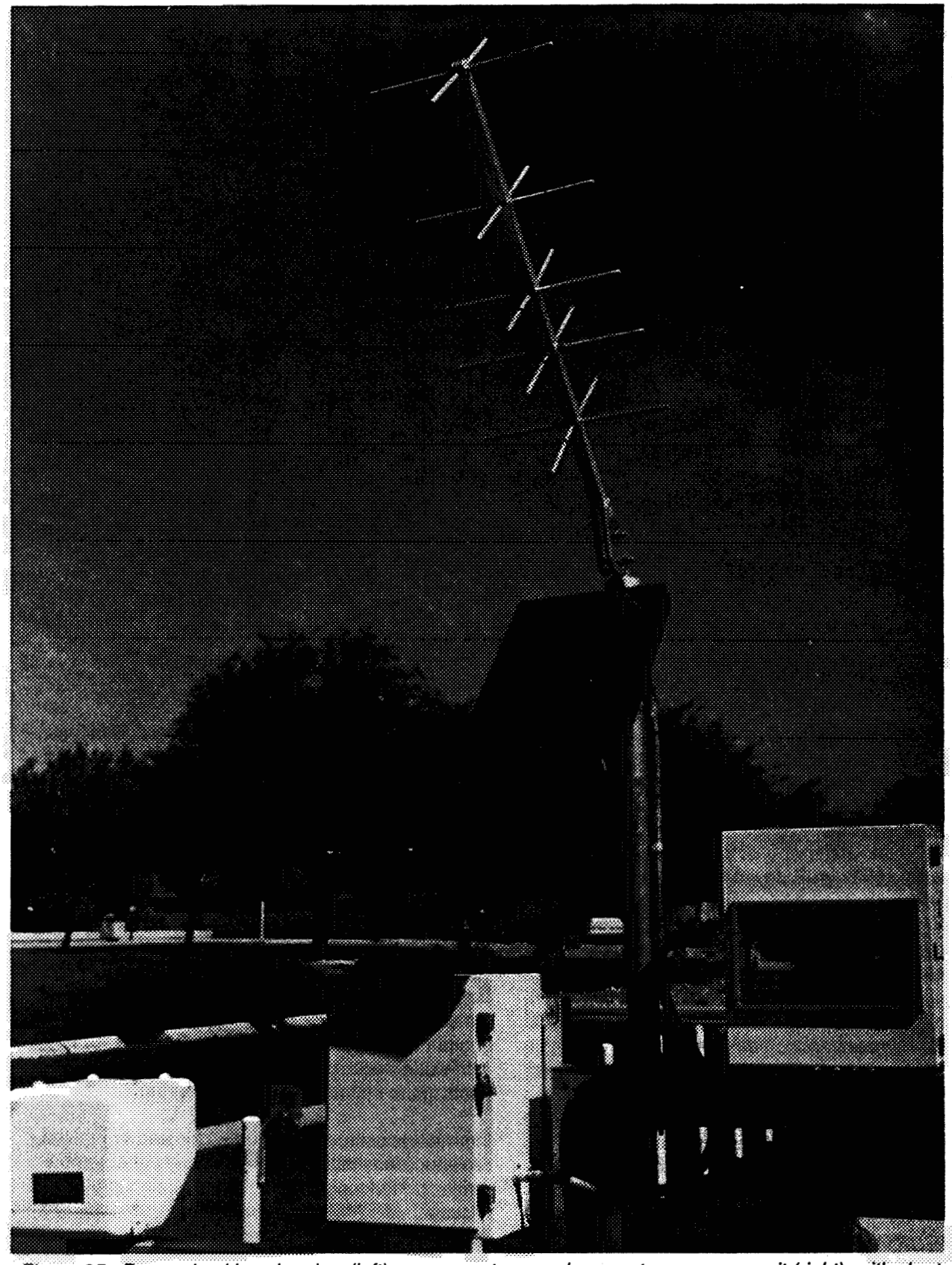

Figure 35. Pressurized ion chamber (left), gamma-rate recorder remote processor unit (right), with chart recorder, digital readout, and telemetry antenna with solar panel (top center).

TABLE 9. PRESSURIZED ION CHAMBER READINGS — 1990

STATION LOCATION	NUMBER OF WEEKLY VALUES	EXPOSURE RATE (μR/hr)[a] MIN	MAX	AVG ± 1 S.D.[b]	mR/yr[c]
ALAMO NV	53	13	14	13 ± 0.3	115
AMARGOSA CENTER NV	52	11	11	11 ± 0.2	96
AMARGOSA VALLEY NV	53	14	15	14 ± 0.3	120
AUSTIN NV	53	14	20	19 ± 1.2	160
BEATTY NV	53	16	17	17 ± 0.3	150
CALIENTE NV	53	14	15	14 ± 0.4	127
CEDAR CITY UT	53	9.5	11	10 ± 0.4	88
COMPLEX I NV	53	15	17	16 ± 0.4	140
DELTA UT	53	11	13	11 ± 0.4	100
ELY NV	53	12	14	13 ± 0.4	110
FURNACE CREEK CA	53	9.4	11	10 ± 0.3	87
GOLDFIELD NV	53	11	16	15 ± 1.2	130
INDIAN SPRINGS NV	53	8.7	9.5	9.0 ± 0.2	79
LAS VEGAS NV	53	5.5	6.2	5.7 ± 0.2	50
MEDLIN'S RANCH NV	53	15	17	16 ± 0.2	140
MILFORD UT	53	16	18	17 ± 0.5	150
NYALA NV	53	12	14	13 ± 0.3	110
OVERTON NV	53	8.7	9.8	9.2 ± 0.2	81
PAHRUMP NV	53	7.4	8.2	7.7 ± 0.2	68
PIOCHE NV	53	11	13	12 ± 0.5	100
RACHEL NV	53	12	18	16 ± 1.5	140
ST. GEORGE UT	53	8.5	9.5	8.9 ± 0.3	78
SALT LAKE CITY UT	53	10	11	11 ± 0.2	95
SHOSHONE CA	53	11	13	12 ± 0.4	100
STONE CABIN RANCH NV	53	16	19	17 ± 0.8	152
TONOPAH NV	53	16	18	16 ± 0.4	140
TWIN SPRINGS RANCH NV	53	16	19	17 ± 0.6	148
UHALDE'S RANCH NV	53	15	18	17 ± 0.7	149

[a] *Weekly averages.*
[b] *Multiply μR/hr by 2.6 x 10^{-10} to obtain C/kg-hr.*
[c] *Multiply mR/yr by 2.6 x 10^{-7} to obtaion C/kg-yr.*

4.2.8.1 System Design

The whole-body counting facility has been maintained at EMSL-LV since 1966 and is equipped to determine the identity and quantity of gamma-emitting radionuclides that may have been inhaled or ingested. Routine examination consists of a 2,000 second count in each of the two shielded examination vaults. In one vault, a single intrinsic germanium coaxial detector positioned over an adjustable chair allows detection of gamma radiation with energies ranging from 60 keV to 2.0 meV in the whole body. The other vault contains an adjustable chair with six intrinsic germanium semi-planar detectors mounted above the chest area as shown in Figure 37. The semi-planar array is designed for detection of gamma and x-ray emitting radionuclides with energy ranges from 10 to 300 keV. Specially designed software allows individual detector spectra to be analyzed to obtain a summation of left- or right-lung arrays and of the total lung area. This provides much greater sensitivity for the transuranic radionuclides but maintains the ability to pinpoint "hot spots." Custom-designed detector mounts allow maximum flexibility for the placement of detectors in various configurations for skull, knee, ankle, or other geometries.

4.2.8.2 Network Design

The Internal Dosimetry Program consists of two portions, an Offsite Internal Dosimetry Program and a Radiological Safety Program. The Offsite Internal Dosimetry Program is designed to: (1) measure radionuclide body burdens in a representative number of families who reside in areas that were subjected to fallout during the early years of nuclear weapons tests, and (2) act as a biological monitoring system for present nuclear testing activities. A few families who reside in areas not affected by such fallout were also selected for comparative study. Members of the general public concerned about possible exposure to radionuclides are also analyzed periodically as a public service.

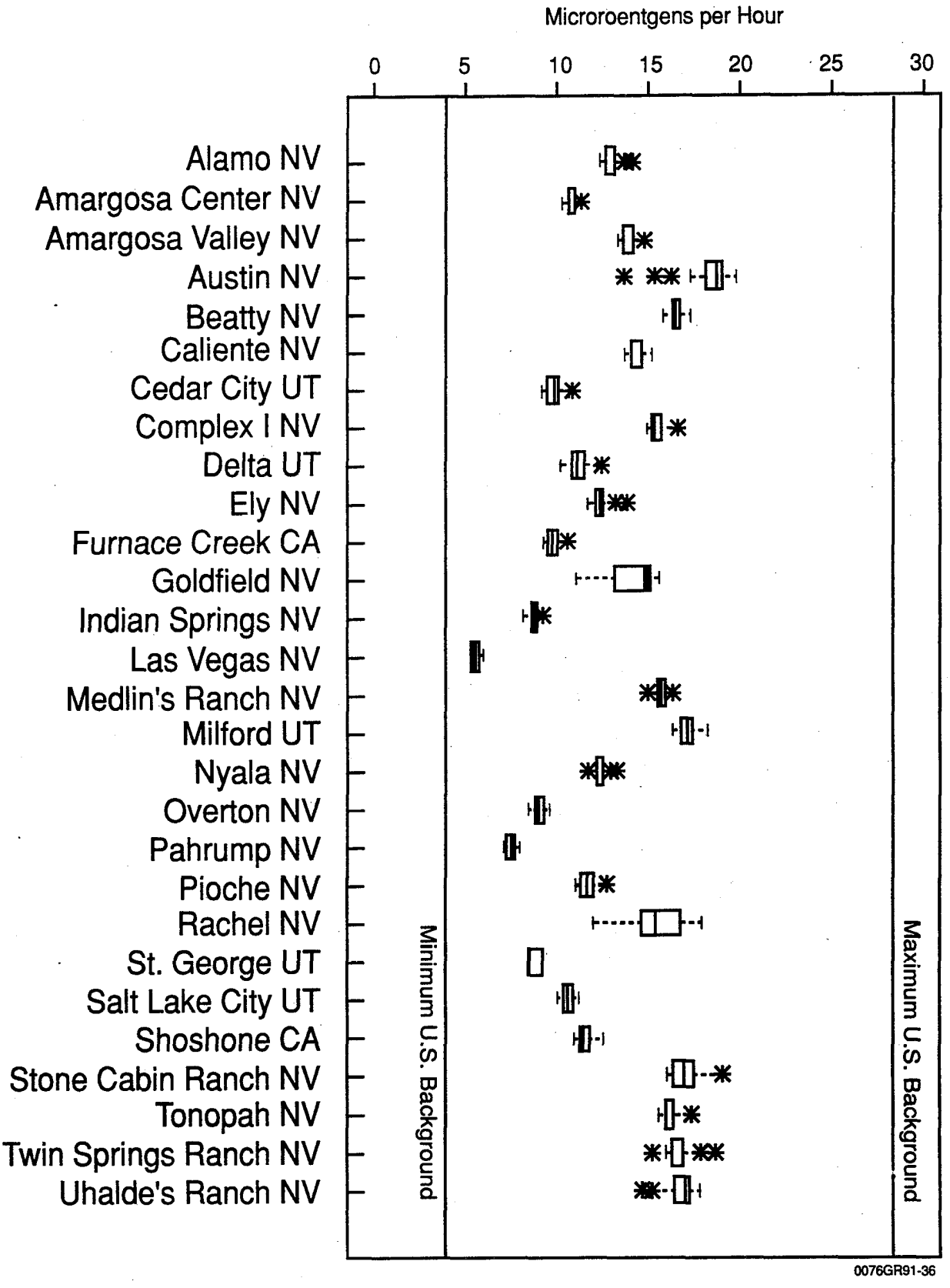

Figure 36. Annual pressurized ion chamber averages by station in microroentgens per hour — 1990.

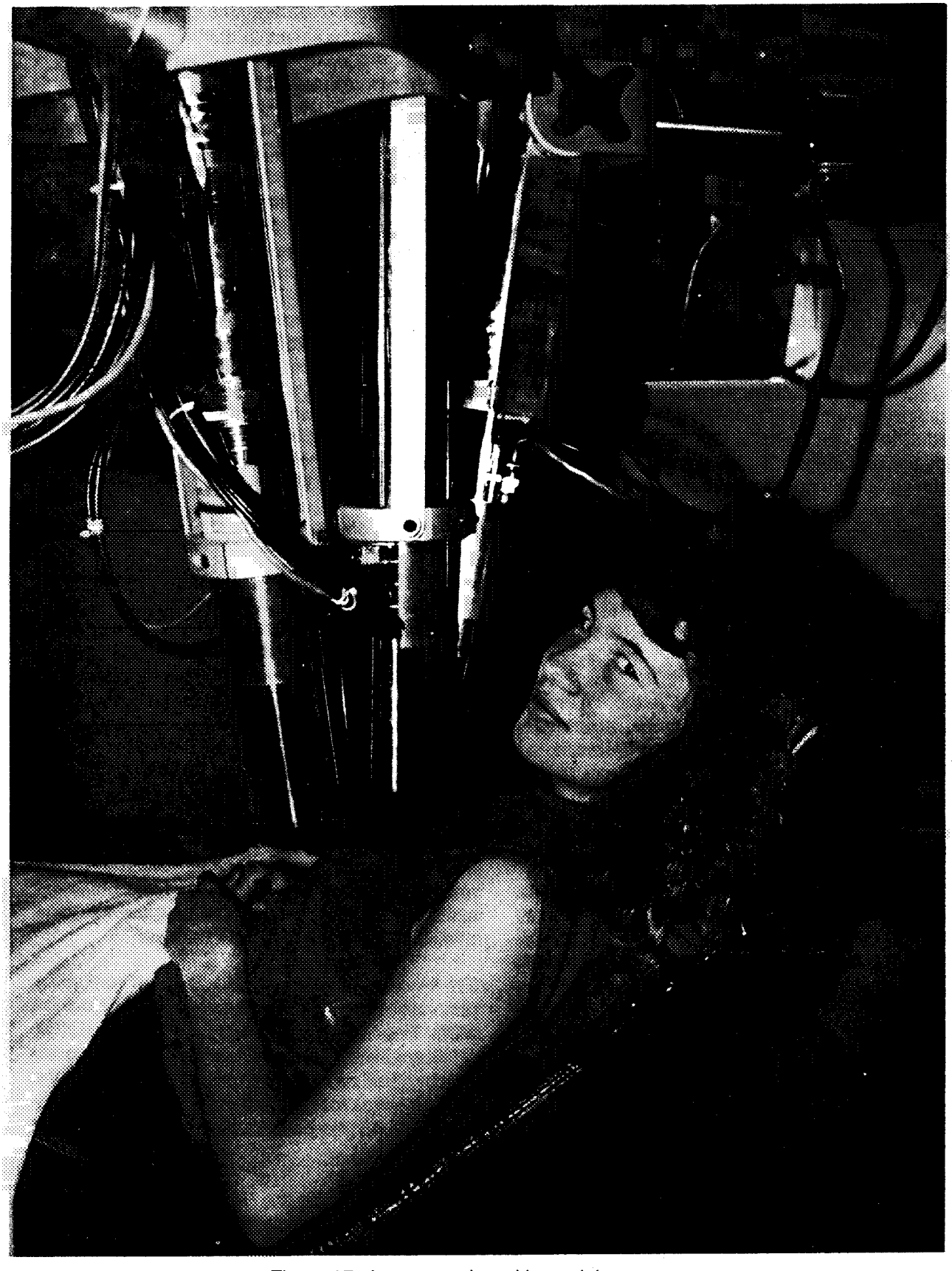

Figure 37. Lung counting with semiplanar array.

The Radiological Safety Program is designed to assess internal exposure for EPA employees, DOE contractor employees, and by special request, for employees of companies who may have had an accidental exposure to radioactive material.

4.2.8.3 Methods

The Offsite Internal Dosimetry Program was initiated in December 1970 to determine levels of radionuclides in some of the families residing in communities and ranches surrounding the NTS. Analyses are performed semiannually, in the spring and in the fall. This program started with 34 families (142 individuals). In 1990, 15 of these families (35 individuals) were still active in the program. When the CMS network was started in 1981, the families of the station managers interested in participating were added to the program. These 23 families (85 individuals) are analyzed in the winter and summer of each year. The geographical locations of the families which participated in 1990 are shown in Figure 38. Although most families are able to come into the laboratory as scheduled, some are unable to participate in a particular year due to distance, weather, or family commitments. All families would presumably be available following any accidental releases of radioactivity.

These persons travel to EMSL-LV where a whole-body and a lung analysis of each person are made to determine the body burden of gamma-emitting radionuclides. A urine sample is collected for ^{3}H analysis. Results of the whole-body and lung analyses are available before the families leave the facility and are discussed with the subjects. At 18-month intervals, a physical exam, health history, and the following are performed: a urinalysis, complete blood count, serology, chest x-ray (three-year intervals), sight screening, audiogram, vital capacity, EKG (over 40 years old), and thyroid panel. The individual is then examined by a physician. The results of the examination can be requested for use by their family physician.

4.2.8.4 Quality Assurance/Quality Control

Quality assurance procedures consist of daily equipment operations checks using QA software obtained specifically for this program. Some of the parameters monitored daily include efficiency calibration of each detector using a NIST-traceable point source to check for zero, gain shift, and resolution over a wide range of energies. A background is also taken once or twice daily depending on the analysis schedule.

The software calculates out-of-range parameter values, flags investigation and action values, and generates a daily QA report. Necessary adjustments are made before any counting of subjects is done. The detector systems are calibrated annually using NIST-traceable phantoms. Intercalibration phantoms are exchanged with other facilities to provide additional QA. Results of all analyses are verified by operational personnel and validated by a health physicist.

Bioassay samples are submitted for radiochemical analysis. Blind duplicates are analyzed for every tenth sample. Intercomparison spiked samples are run periodically. All analytical results are reviewed by a health physicist and dose calculations are performed using verified software utilizing International Commission on Radiological Protection (ICRP)-30 methodology (ICRP79).

4.2.8.5 Results

During 1990, a total of 1,500 gamma spectra were obtained from 236 individuals, of whom 120 were participants in the Offsite Internal Dosimetry Program. In general, the spectra were representative of normal background for people and showed only naturally occurring ^{40}K, and radon and thoron daughter products. No transuranic radionuclides were detected in any lung analysis data.

Several employees of a waste processing plant in Utah were flown down after a small contaminating event occurred. No contamination was detected in any of the employees. Several visiting scientists from Europe were counted. A very small amount of cesium is still present in some of these individuals as a result of the Chernobyl accident.

The ^{3}H concentrations in urine samples from occupationally exposed persons were mostly below the MDC. The highest concentration, 1.9×1.0^{-6} µCi/mL (70 Bq/mL) was in an individual wearing a tritium dial watch. This amount was only eight percent of the allowable limit for occupationally exposed individuals. Table A6 (Appendix) presents analytical results for 1990.

Bioassay results for the Offsite Internal Dosimetry Program showed that the ^{3}H concentration in single urine samples collected at random periods of time

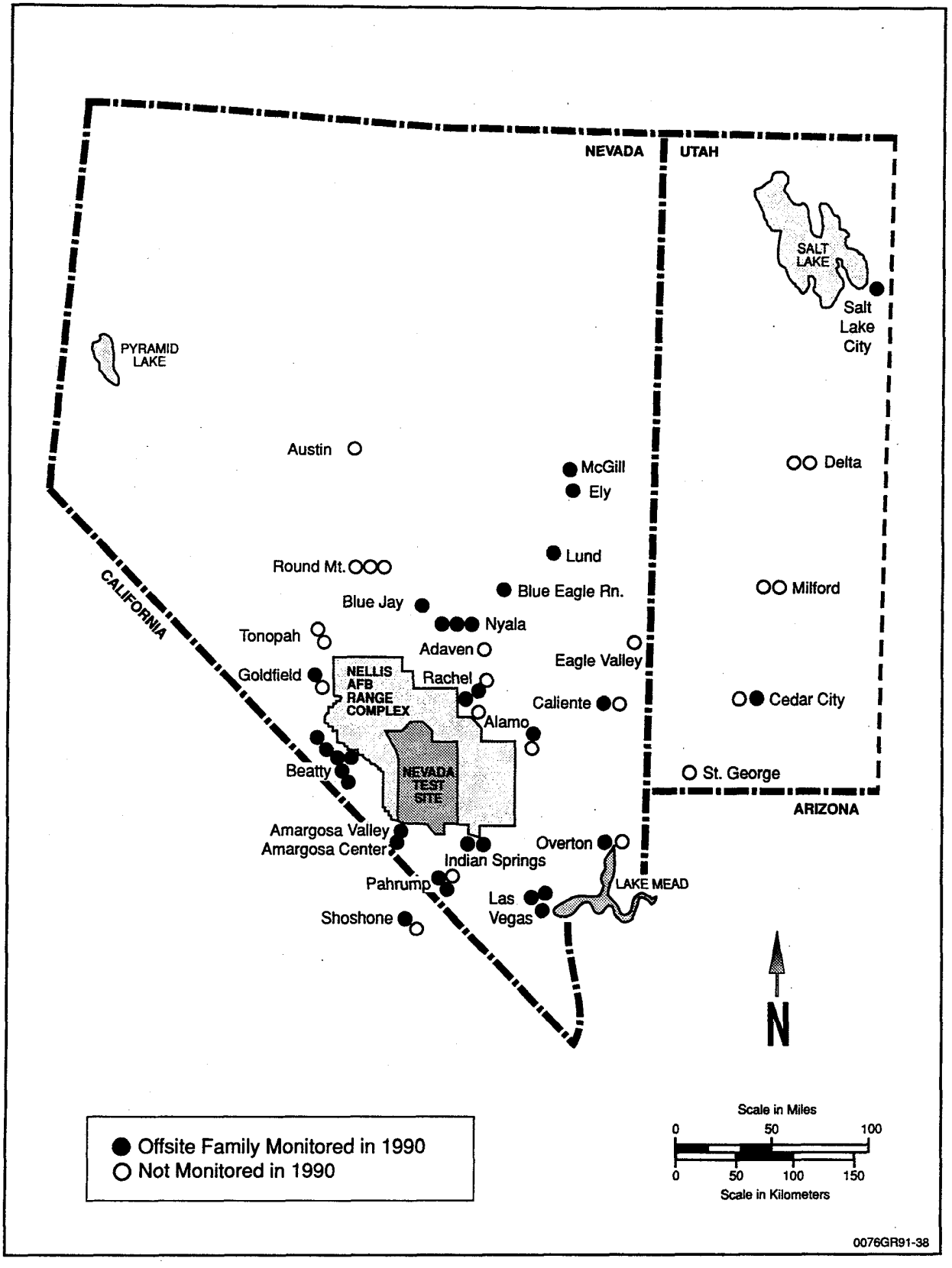

Figure 38. Location of families in the Offsite Internal Dosimetry Program.

varied from below the MDC of about 3.0×10^{-7} µCi/mL (11 Bq/L) to 5.5×10^{-7} µCi/mL (20 Bq/L). The average value for 115 samples analyzed for ^{3}H in urine was 1.0×10^{-7} µCi/mL (3.7 Bq/L). Only four percent of the concentrations were above the MDC. None of the values above the MDC were over applicable limits. The highest value, 5.5×10^{-7} µCi/mL, was 0.3 percent of the annual limit on radionuclide intake for the general public. Analytical results are shown in tabular form in Table A7 (Appendix). The higher than MDC tritium values seen in the offsite population occur routinely. There appears to be no correlation with ^{3}H found in air samples. Biological indicators of exposure have been shown to be much more sensitive than instruments as they concentrate the activity over time. The urine samples can be used only as an indicator of exposure as they are taken on a random basis; e.g., sampling is not correlated to radioactivity release or weapons testing dates.

The box-and-whisker plots (Figure A22 in the Appendix) indicate the distribution of ^{3}H concentrations in samples from residents of Overton and Rachel, NV, and Cedar City, UT. Values higher than the MDC have occurred occasionally over the past ten years due to controlled atmospheric effluent releases but no exposures over allowable limits for the general population have occurred.

As reported in previous years, medical examinations of the offsite families revealed a generally healthy population. The blood examinations and thyroid profiles showed no abnormal results which could be attributed to radionuclide exposure; hence results are not attributable to past or present NTS testing operations. As no planned releases of radioactivity occurred from the NTS, no additional bioassay sampling was done in 1990.

4.2.9 Long-Term Hydrological Monitoring Program

W.G. Phillips

Tritium and gamma-spectral analyses were performed on samples taken from 265 wells, springs, and other sources at locations near sites where underground nuclear explosives tests have been conducted. Man-made gamma radioactivity was found in only three sampled locations. Tritium concentrations found during this sampling year were consistent with the levels found in previous years. The tritium concentrations were greater than the EPA Drinking Water Standards (CFR88) in only three samples from wells in New Mexico not accessible to the general public.

4.2.9.1 Background

Surface and ground water sampling have been performed for many years on water sources around the NTS (Figure 39). Also, when underground nuclear tests occurred in other states, water sampling programs were instituted. Finally, in 1972 all of the water sampling programs were combined to constitute the LTHMP. At each of the sites of underground nuclear tests, water sampling points were established by the U.S. Geological Survey (USGS) so that any migration of radioactivity from the test cavities to potable water sources could be detected by radioanalysis.

Much emphasis is placed on ^{3}H analysis of ground water samples. Following an underground nuclear test, most of the radioactive materials that are created decay away very quickly. Most of those remaining are captured in the molten rock created by the explosion and in the surrounding rock itself. Tritium, a radioactive form of hydrogen, is naturally occurring and is also a product of nuclear explosions. It becomes incorporated into water molecules and moves with the ground water flow. For this reason, the first indication of the migration of the radioactive materials created from nuclear explosions is the migration of ^{3}H.

4.2.9.2 Design and Methods

Sampling in the LTHMP is conducted near locations of underground nuclear explosive tests throughout the U.S. This includes the NTS, two sites in Nevada not on the NTS, and sites in Alaska, Colorado, New Mexico, and Mississippi. In 1990, LTHMP activities focused on the NTS and on Tatum Dome, MS, site of Project Dribble. Twenty-eight wells on the NTS plus one well adjacent to the NTS and 35 sampling locations in areas near the NTS that are part of this program are shown in Figures 40 and 41, respectively. A comprehensive sampling program was conducted in the vicinity of Tatum Dome in 1990. Samples from many media were collected (Section 4.2.10). In addition, several residents requested that their water be analyzed because of news reports of leakage from the Project Dribble test cavity. The locations of sampling points used to monitor specific nuclear tests at sites in Nevada, Colorado, Mississippi, and New Mexico are shown in Figures A23

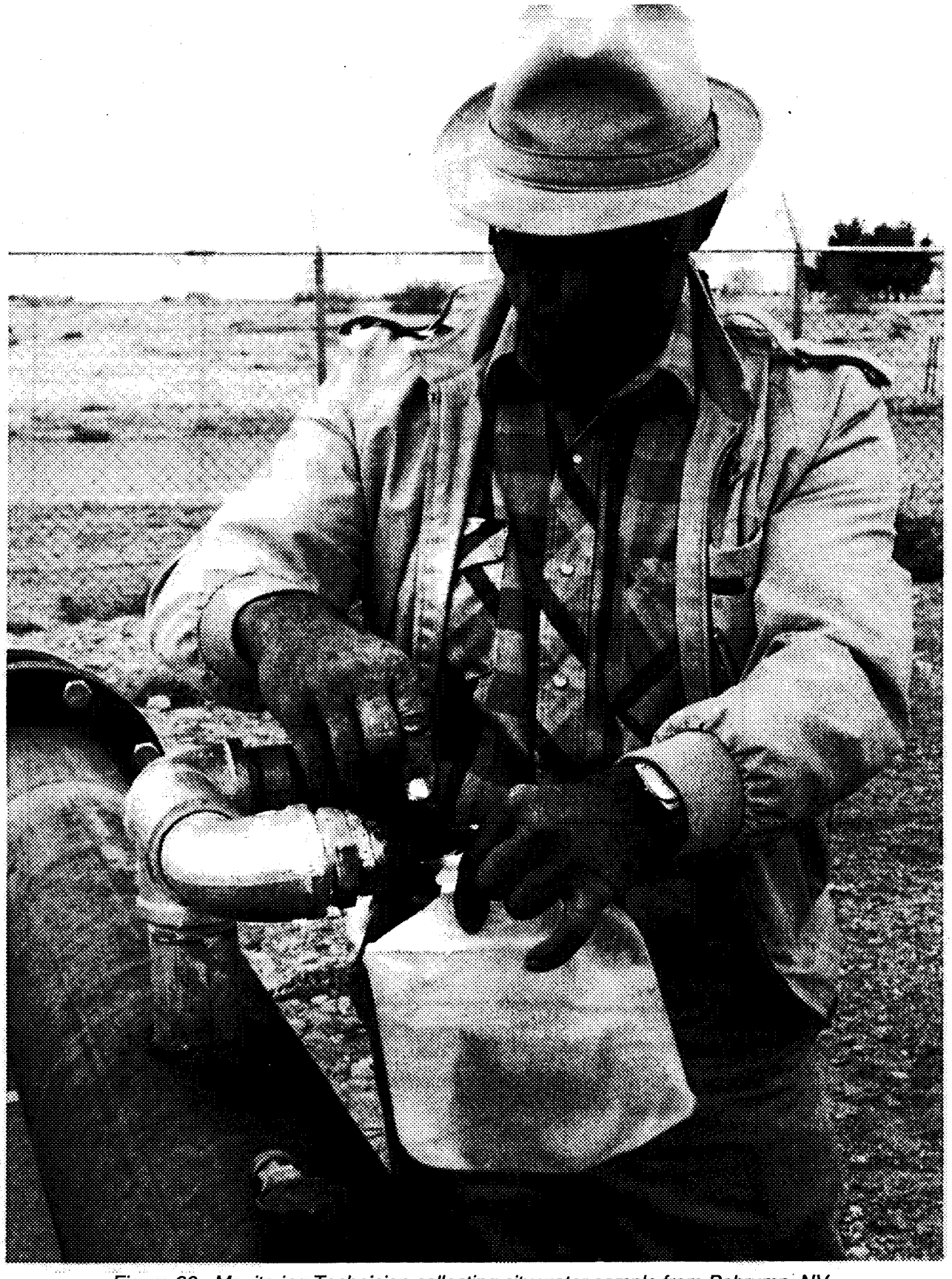

Figure 39. Monitoring Technician collecting city water sample from Pahrump, NV.

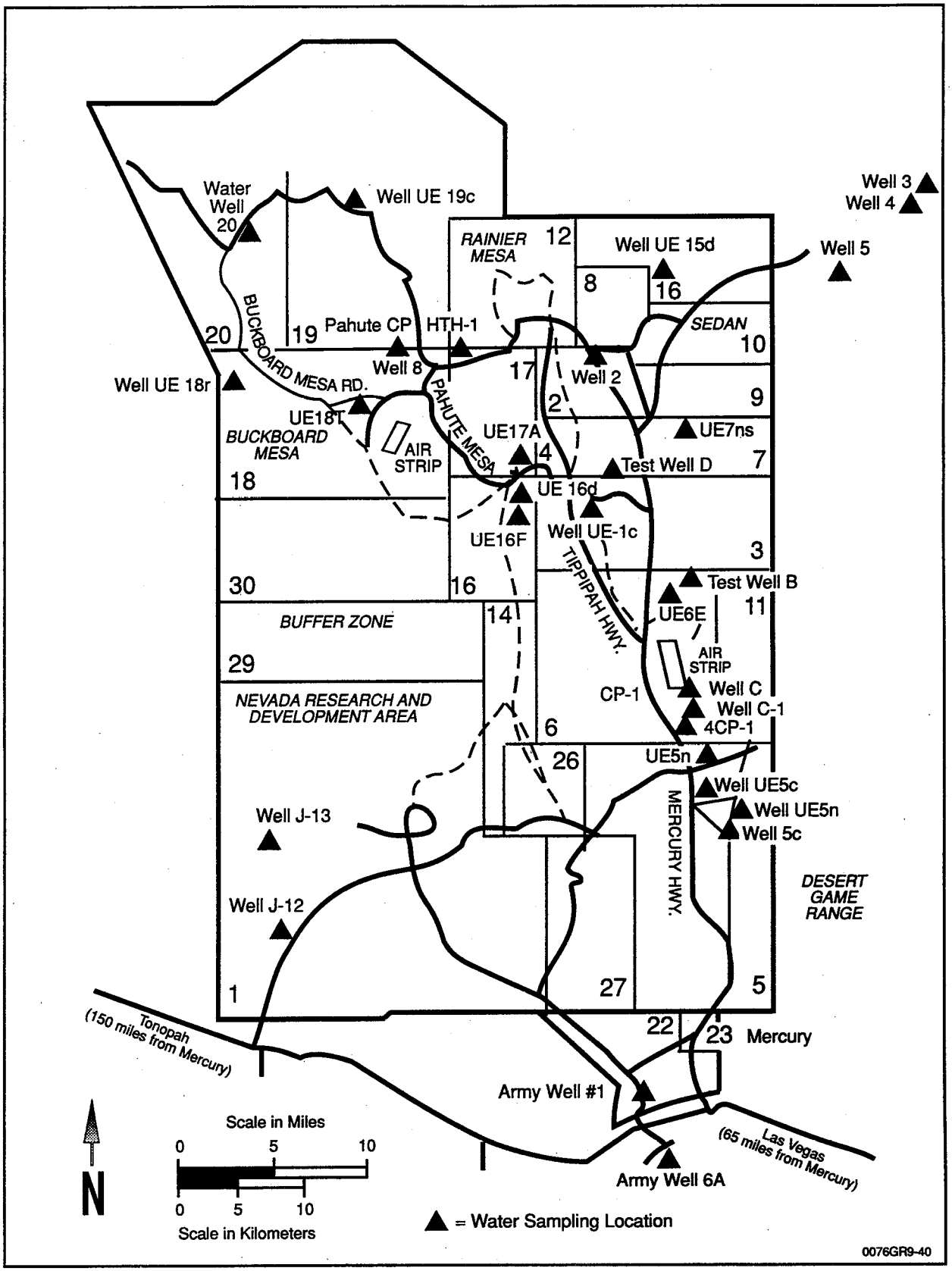

Figure 40. Long-Term Hydrological Monitoring Program sampling locations on the Nevada Test Site.

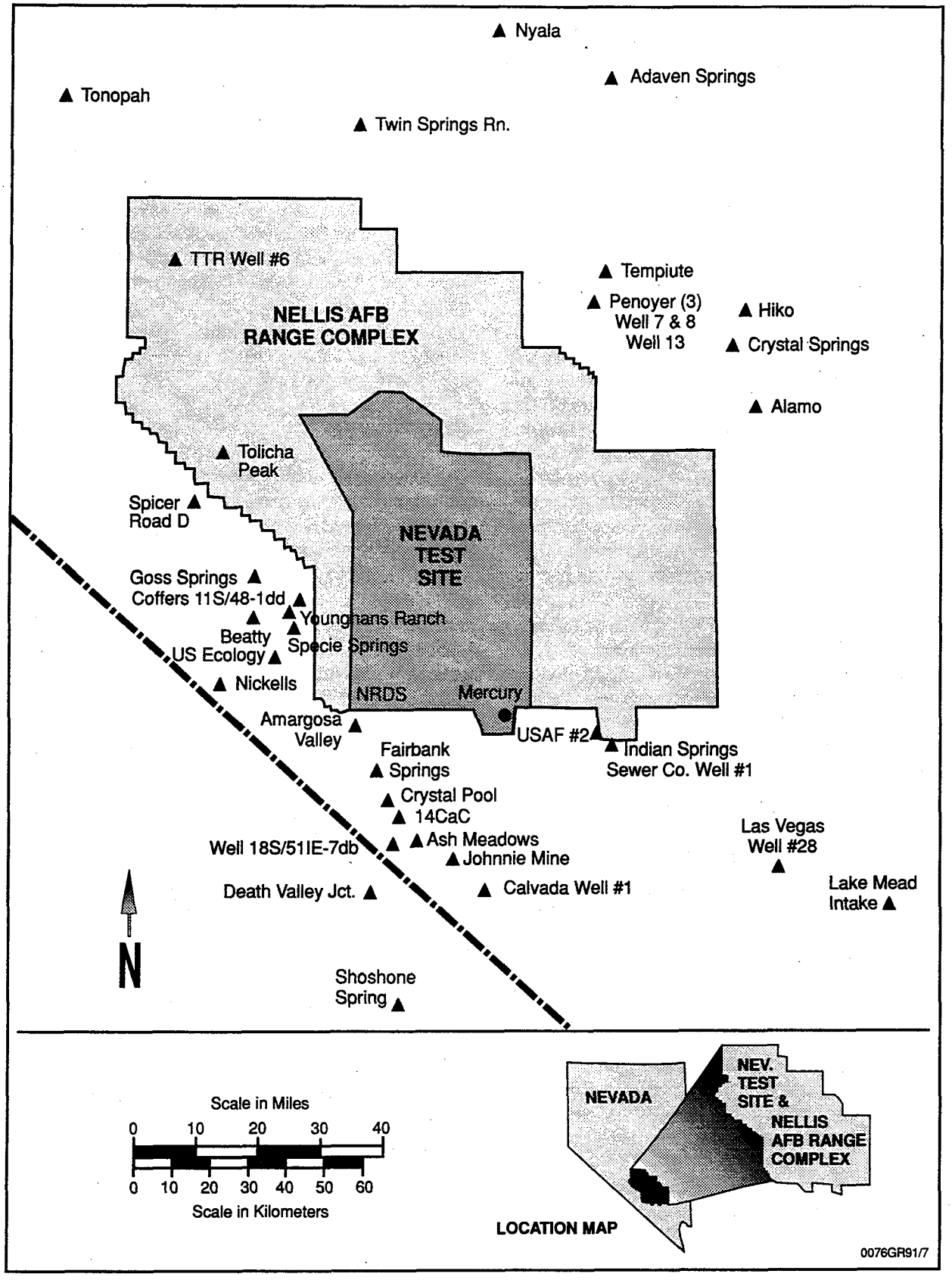

Figure 41. Long-Term Hydrological Monitoring Program sampling locations near the Nevada Test Site.

through A30 (Appendix). Sites in Alaska were not sampled in 1990. Those sites will be sampled in 1991 and every two years thereafter.

At nearly all locations, the standard procedure is to collect four samples. Two samples are collected in 500-mL glass bottles to be analyzed for ^{3}H. The analysis results of one of these are reported while the other sample serves as a backup in case of loss. If ^{3}H is found at a detectable concentration, the second sample serves as a duplicate sample. The remaining two samples are collected in 1-gallon (3.8-L) plastic containers (Cubitainers). One of these is analyzed by gamma spectrometry and the other is stored as a backup or for duplicate analysis. For wells with operating pumps, the samples are collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling rig is used. With this rig, it is possible to collect 3-L samples from wells as deep as 5,900 feet (1800 m). At a few locations, because of limited supply, only 500-mL samples are collected for ^{3}H analysis. At the normal sample collection sites, pH, conductivity, and water temperature are measured at the time the sample is collected. The first time samples are collected from a well, $^{89,90}Sr$, ^{226}Ra, $^{238,239+240}Pu$, and uranium isotopes are determined by radiochemistry as time permits. The ^{3}H and gamma spectrometric analytical methods are described in Chapter 8. For those samples in which the ^{3}H concentration is less than 7×10^{-7} µCi/mL (26 Bq/L), an enrichment procedure is performed to reduce the MDC from about 5×10^{-7} to about 1×10^{-8} µCi/mL (from 18 to 0.4 Bq/L).

For those operations conducted in states other than Nevada, samples for the LTHMP are collected annually. For the locations on the NTS listed in Table 10, the samples are collected monthly, when possible, and analyzed by gamma spectrometry as well as for ^{3}H. For a few NTS wells and for all the water sources around the NTS shown in Table A8 (Appendix), a sample is collected twice per year at about a 6-month interval. One of the semiannual samples is analyzed for ^{3}H by the conventional method, the other by electrolytic enrichment. A 3.8- L Cubitainer of water is collected each month from these sites and analyzed by gamma spectrometry.

The standard collection procedure is modified for samples collected in the Tatum Dome, MS area. Because of the variability noted in past years in samples obtained from the shallow monitoring wells, a second sample is taken after pumping for awhile or after the hole has refilled with water. These second samples are frequently higher in ^{3}H concentration and may be more representative of formation water.

4.2.9.3 Quality Assurance/Quality Control

As described in Chapter 6, duplicate analyses, matrix spikes, blanks, blinds, and reference standards are utilized to guarantee the highest possible quality in all water analyses. As a general radioanalytical procedure, a minimum of ten percent of the work load are QC samples. Table 11 is a breakdown of the frequencies for each type of QC sample in the water matrix. In addition, each analysis technique must prove to be accurate to within various predefined control limits. Table 12 is a chart of these tolerance limits for the water matrix.

4.2.9.4 Results

The locations at which the water samples contain man-made radioactivity are shown in Table 13 along with the analytical results. For ^{3}H, only those samples having a concentration exceeding one percent of the EPA Drinking Water Standards, i.e. > 2.0×10^{-7} µCi/mL are shown. The activity in Well LRL-7 is expected since it is linked to the Gnome test cavity. Results for the USGS wells 4 and 8 are also expected because radioactivity was added to the aquifer for hydrological testing. The ^{3}H in samples from Project Dribble are a result of postshot drilling operations and disposal of low-level contaminated debris. Except for three samples listed in Table A8 (Appendix), all the gamma spectra were negligible (no measurable gamma-emitting fission products over the energy range 60 to 2,000 keV). Results are listed in Tables 10, 13, and A8 (Appendix).

Table 10 shows the maximum, minimum, and average ^{3}H concentrations found in the NTS wells that are sampled monthly. Shown in Table 13 are the ^{3}H results for those onsite and offsite water sources that are analyzed semiannually. Finally, Table A8 (Appendix) contains the ^{3}H concentration in water samples collected around sites used for underground nuclear tests that were performed outside the NTS.

4.2.9.5 Discussion

The results for the residents' special request samples are shown in Table A8 (Appendix) at the end of the Project Dribble listing. The ten-year trend of activity concentrations of ^{3}H for two wells which have traditionally shown man-made radioactivity are plotted in Figure A31 (Appendix). These wells are typical of

those at each of the four locations that show positive activity.

The first six plots of Figure A32 (Appendix) are of single yearly values except for two samples in 1984 for Dribble Well HM-S and two samples in 1985 for Dribble Well HMH-2. The last two plots, for NTS test wells C and C1, depict multiple analyses for each year. In each case, the general trend is for declining activity concentrations with time.

Regardless of the finding of detectable amounts of radioactivity in some water samples, the exposure to the public is negligible. The HMH holes at Project Dribble tap shallow, nonpotable water and the HM-S and HM-L wells are locked. The wells at the Gnome site are locked and inaccessible to the general public while the EPNG well at the Gasbuggy site is a monitoring well with no pump.

4.2.10 Special Environmental Surveillance

C.A. Fontana and D.D. Smith

During the spring of 1990, an intensive sampling program was conducted on and around the Tatum Salt Dome site in Lamar County, MS (Project Dribble). This study was designed to document any migration or lack of migration of radioactive materials (especially ^{3}H) from the original test cavity.

Animal sampling was included in the study since animals are a possible pathway of radioactive material to humans. A steer and a goat living near the Tatum Salt Dome were purchased and samples of their muscle, liver, bone, and blood were analyzed. Samples of wild turkey, deer, catfish, and a turtle were collected on or near the Tatum Salt Dome site. Control samples from a Columbia, MS, steer were purchased at a packing plant and four deer were collected on the Red Creek Wildlife Management Area in southern Mississippi. None of the animals contained tissue ^{3}H levels above the MDC, approximately 520 pCi/L (1.9×10^{8} Bq/L). The maximum ^{137}Cs concentration found in the Tatum Salt Dome deer muscle was 0.5 pCi/g (18 Bq/kg), which is the same order of magnitude of levels of ^{137}Cs found in the control deer. Similar levels have also been reported from South Carolina deer (SRS89). The source of ^{137}Cs is global fallout from atmospheric nuclear testing.

Two nuclear and two nonnuclear detonations were conducted in the Tatum Salt Dome in Lamar County, MS, between 1964 and 1970. Local residents have expressed concern of possible health effects attributed to the nuclear detonations conducted in the Tatum Dome. Because of this concern, EPA increased the scope of the radiological sampling activities in 1990 to include:

- Urine samples from nearby residents.
- Vegetable and soil samples from local gardens.
- Milk samples from goats and cows.

TABLE 10. LONG-TERM HYDROLOGICAL MONITORING PROGRAM TRITIUM RESULTS FOR NEVADA TEST SITE MONTHLY NETWORK — 1990

SAMPLING LOCATION	NUMBER OF SAMPLES	TRITIUM CONCENTRATION (10^{-9} µCi/mL) MAX	MIN	AVG	PERCENT OF CONCENTRATION GUIDE
WELL 1 ARMY	12	3.2	–4.5	–0.30	<0.01
WELL 2	12	3.3	–4.9	–0.91	<0.01
WELL 3	4	3.7	–2.3	2.0	<0.010
WELL 4	12	4.9	–4.0	0.68	<0.01
WELL 4 CP-1	11	8.7	–3.6	0.84	<0.01
WELL 5	12	9.4	–1.6	2.6	0.013
WELL 5C	12	4.5	–7.8	–0.48	<0.01
WELL 8	12	7.8	–5.4	–0.16	<0.01
WELL 20	12	5.2	–3.6	–0.21	<0.01
WELL B TEST	11	140	57	100	0.52
WELL C	12	70	–2.2	18	0.092
WELL J-12	12	2.0	–4.1	–0.78	<0.01
WELL J-13	12	8.6	–4.9	–0.43	<0.01
WELL UE19C	12	3.8	–6.8	–0.50	<0.01

TABLE 11. WATER ANALYSIS QUALITY CONTROL

ANALYSIS	FREQ. (% BLANK)	FREQ. (%DUP.)	FREQ. (%SPIKE)	FREQ. (% BLIND)
^{3}H (conventional)	4	3	2	1
^{3}H (enrichment)	3	3	3	1
^{89}Sr,^{90}Sr	3	3	3	1
Gross Alpha/ Gross Beta	3	3	3	1
Gamma Scan	8	10	3	1

TABLE 12. WATER ANALYSIS CONTROL LIMITS

ANALYSIS	CONTROL LIMIT (±%)
^{3}H (conventional)	10%
^{3}H (enriched)	20%
^{89}Sr,^{90}Sr	20%
Gross Alpha, Gross Beta	20%
Gamma Scan	20%
MATRIX SPIKE CONTROL LIMITS	
^{3}H (conventional)	10%
^{3}H (enriched)	20%
^{89}Sr, ^{90}Sr	20%
Gross Alpha, Gross Beta	20%
Gamma Scan	20%

TABLE 13. SAMPLING LOCATIONS WHERE WATER SAMPLES CONTAINED MANMADE RADIOACTIVITY

SAMPLING LOCATION	RADIONUCLIDE	CONCENTRATION 10^{-9} µCi/mL
PROJECT GNOME NM		
Well DD-1	^{3}H	2.8×10^{7}
	^{137}Cs	7.9×10^{5}
	^{40}K	7.6×10^{3}
	^{89}Sr	-1.9×10^{1}
	^{90}Sr	8.2×10^{3}
	^{238}Pu	5.4×10^{-2}
	$^{239+240}Pu$	1.1×10^{0}
Well LRL-7	^{3}H	1.4×10^{4}
	^{137}Cs	1.8×10^{2}
Well USGS 4	^{3}H	1.5×10^{3}
Well USGS 8	^{3}H	1.2×10^{5}
	^{137}Cs	6.4×10^{1}
PROJECT GASBUGGY NM		
Well EPNG-10-36	^{3}H	2.3×10^{2}
PROJECT RIO BLANCO CO		
CER No. 1 BLACK SULFUR	^{3}H	3.5×10^{2}
PROJECT DRIBBLE MS		
Well HMH-1	^{3}H	4.0×10^{3}
Well HMH-2	^{3}H	8.2×10^{3}
Well HMH-5	^{3}H	1.9×10^{3}
Well HMH-16	^{3}H	9.7×10^{2}
Well HMH-L	^{3}H	1.1×10^{3}
Well HMH-S	^{3}H	9.4×10^{3}
Half Moon Creek	^{3}H	3.0×10^{2}
Half Moon Creek Overflow	^{3}H	4.5×10^{2}
Lower Little Creek	^{3}H	6.8×10^{2}

- Offsite and onsite atmospheric moisture monitoring.
- Onsite atmospheric particulate monitoring.
- Onsite deer, turkey, catfish, and turtle tissue samples.
- Onsite soil, sediment, and vegetation samples.
- Offsite and onsite water samples for radiological and nonradiological analysis (volatile organics, semivolatile organics, pesticides, and heavy metals).
- Five additional shallow onsite wells.
- Cow tissue samples.
- Goat tissue samples.

In all of the offsite samples, including human bioassay samples, no radioactive materials from the Tatum Dome site were detected. Only background levels of no health consequence were found. Although decreasing, ^{3}H contamination was detected in some onsite water samples. These levels were so low that the onsite water meets the EPA criterium for drinking water (CFR88). No other radioactive material above background was detected onsite or offsite. The analysis of onsite water samples for nonradioactive hazardous materials revealed very low level concentrations of only a few organic chemical contaminants of unknown origin. No health effects would be expected from the contaminants at the concentrations found. The complete set of analytical data resulting from radiological monitoring at Tatum Salt Dome was published in EPA's "Onsite and Offsite Environmental Monitoring Report: Radiation Monitoring Around Tatum Salt Dome, Lamar County, Mississippi, April 1990" (EPA91B).

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5 Public Information and Community Assistance Programs

D. J. Thomé

In addition to its many monitoring and data analysis activities, the EPA EMSL-LV conducts a comprehensive program designed to provide information and assistance to individual citizens, organizations, and local government agencies in communities in the vicinity of the NTS. Activities in 1990 included: participation in public hearings, "town hall" meetings, continued support of the CMS Program, and a variety of tours, lectures, and presentations.

5.1 COMMUNITY MONITORING STATION PROGRAM

Beginning in 1981, DOE and EPA established a network of CMSs (Figure 42) in the offsite areas to perform radiological sampling and monitoring, to increase public awareness, and to disseminate the results of radiation monitoring activities to the public. These stations continued operation in 1990. The DOE, through an interagency agreement with EPA, sponsors the program. The EPA provides technical and scientific direction, maintains the instrumentation and sampling equipment, analyzes the collected samples, and interprets and reports the data. The Desert Research Institute of the University of Nevada administers the program by hiring the local station managers and alternates, securing right-of-way and utility meters, and by providing QA checks of the data. The University of Utah provides in-depth training twice a year on all issues related to nuclear science, radiological health, and radiation monitoring. In each community, EPA and DRI work with civic

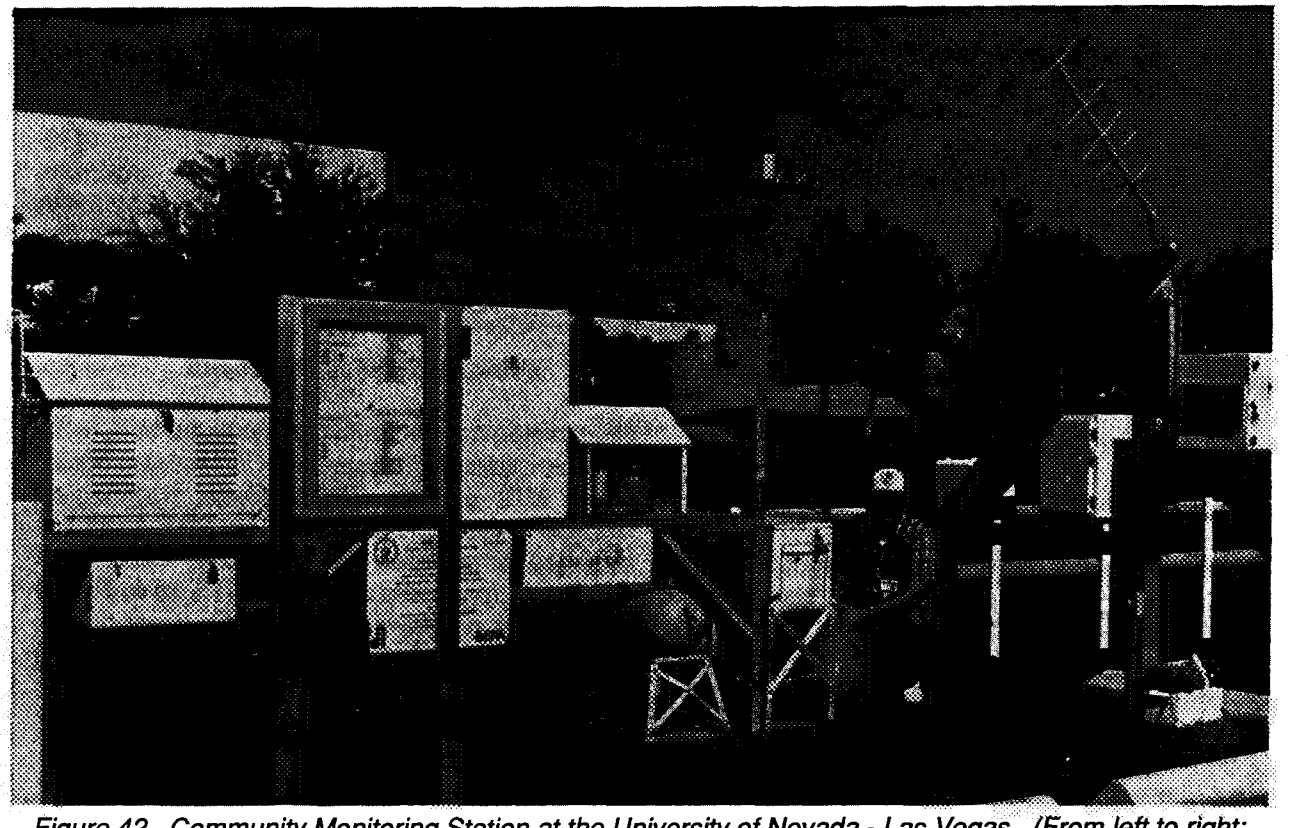

Figure 42. Community Monitoring Station at the University of Nevada - Las Vegas. (From left to right: particulates and reactive gases sampler, tritium sampler, microbarograph, noble gas sampler, gamma radiation exposure rate recorder, and thermoluminscent dosimeter.)

leaders to select and hire a local manager and an alternate. Whenever possible, they choose residents with some scientific training, such as a high school or university science teacher.

All of the 19 stations contain one of the samplers for the ASN, NGTSN, and TLD networks discussed in the previous chapter. Each station contains a PIC with a recorder for immediate readout of external gamma exposure and a recording barograph. All of the equipment is mounted on a stand at a prominent location in each community so the residents are aware of the surveillance and, if interested, can have ready access to the PIC and barometric data. The data from these stations are included in the tables in Chapter 4 with the other data from the appropriate networks. Table 9 (Section 4.2.7) contains a summary of the PIC data.

Computer-generated reports for each station are issued weekly. These reports indicate the current weekly PIC average, the average over the previous week, and the average for the previous year. These reports additionally show the maximum and minimum background concentrations in the U.S. In addition to being posted at each station, copies are sent to appropriate federal and state personnel in California, Nevada, and Utah. All of the CMSs are equipped with satellite telemetry transmitting equipment. With this equipment, gamma exposure measurements acquired by the PICs are transmitted, via GOES, directly to the NTS and from there to EMSL-LV by dedicated telephone line. The transmission of these data occurs automatically every four hours. However, whenever the gamma exposure measurements at any station exceeds 50 μR/hr, that station goes into an emergency mode and transmits data every minute. This continues until the measurement is again less than 50 μR/hr, at which time the PIC reverts to its routine condition.

5.2 TOWN HALL MEETINGS

Ninety-four town hall meetings have been conducted since 1982. These meetings provide an opportunity for the public to meet directly with EPA, DOE, and DRI personnel, ask questions, and express their concerns regarding nuclear testing. During a typical meeting, the procedures used and the safeguards in place during every nuclear test are described. The EPA's radiological monitoring and surveillance networks are explained and the proposed High Level Waste Repository at Yucca Mountain is discussed.

In addition to the regular town hall meetings held in 1990, similar presentations and presentations devoted solely to EPA's ORSP were presented to various groups such as chambers of commerce, League of Women Voters, senior citizens, high schools, and the press. Four town meetings were held in Lamar County, MS to explain what took place at the Tatum Dome Nuclear Test Site and the results of EPA's onsite and offsite radiological monitoring activities. These meetings were held in response to concerns expressed by residents about possible health effects originating from the Tatum Dome site. The locations of the 1990 meetings were as follows:

Location	Date
Lumberton, MS	08/29/90
Columbia, MS	08/29/90
Purvis, MS	08/28/90
Baxterville, MS	08/27/90
Hattiesburg, MS - Press	08/27/90
Mesquite, NV	06/28/90
Bunkerville, NV	06/27/90
Dolan Springs, AZ	05/24/90
Alamo, NV	04/17/90
Rachel, NV	04/16/90
Las Vegas, NV - League of Women Voters	03/24/90
Bishop, CA	02/15/90
Bishop, CA - Chamber of Commerce	02/15/90
Bishop, CA - High School	02/15/90
Pahrump Valley, NV	02/09/90
Pahrump Valley High School, NV	02/09/90
Pahrump Valley Senior Citizen Center, NV	02/09/90

5.3 NEVADA TEST SITE TOURS

To complement the town hall meetings and to familiarize citizens with both the DOE testing program at the NTS and the Environmental Radiological Monitoring Program conducted by EPA, tours are arranged for business and community leaders and individuals from towns around the NTS, as well as for government employees and for the news media. Between January and December 1990, the following tours were sponsored by the EPA:

U.S. Congressional Working Group Staff Members	12/07/90
EPA Employees and Dependents	12/06/90

EPA Headquarters Workforce Development Office and the National Association for Hispanic Elderly	08/21/90
EPA Headquarters Office of Modeling, Monitoring Systems, and Quality Assurance	06/26/90
EPA Agency-Wide Secretaries Advisory Council	05/10/90
Public Officials and Residents of Kingman, AZ	04/2 and 3/90
Residents of Ely, NV	03/21 and 22/90
Residents of Beatty and Tonopah, NV	02/22 and 23/90
EPA Headquarters Senior Management	02/06/90

5.4 ANIMAL INVESTIGATIONS

One of the public service functions of EMSL-LV is to investigate claims of injury allegedly due to radiation originating from NTS activities. A veterinarian, qualified by education and experience in the field of radiobiology, investigates questions about domestic animals and wildlife to determine whether radiation exposure may be involved. No animal investigations were requested during 1990.

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6 Quality Assurance and Procedures

D. G. Easterly and C. A. Fontana

The QA program conducted by EMSL-LV for the ORSP includes: SOPs, DQOs, data validation, QC, health physics oversight, and monitoring precision and accuracy of analyses. Duplicate samples are analyzed for the ASN, NGTSN, MSN, TLD, and LTHMP networks. The coefficient of variation of replicate samples for these networks varied from a median value of 0.5 percent for the MSN tritrium analyses to 22 percent for the TLD network over 1990. Comparisons of EMSL-LV- and DOE-generated data indicate good correlation between the two laboratories. The results of participation in the EPA QA Intercomparison Study Program indicated that the analytical procedures were in control for analyses conducted in 1990.

6.1 POLICY

One of the major goals of EPA is to ensure that all decisions which are dependent on environmental data are supported by data of known quality. Agency policy initiated by the EPA Administrator in memoranda of May 30, 1979, and June 4, 1979, requires participation in a centrally managed QA Program by all EPA Laboratories and those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements. Further, by Order 5360.1, EPA policy requires participation in a QA Program by all organizational units involved in environmental data collection.

EMSL-LV's QA policies and requirements are summarized in EPA/600/X-87/241, Quality Assurance Program Plan (EPA87), and are fully adhered to within the ORSP.

6.2 STANDARD OPERATING PROCEDURES

Elements of the QA program include local SOPs which define methods of sample collection, handling, control, analysis, data validation, interpretation, and reporting. These SOPs support the goal of the QA program in maintaining the quality of results within established limits of acceptance, with the primary purpose of assessing the effects of human exposures to radiological hazards in the environment.

These SOPs describe the extent of QC practices conducted within the radioanalytical laboratory. The SOP describes what activities are to be performed and includes complete instructions for preparation and use of control charts, use of spiked samples for accuracy and precision determinations, and other activities used for controlling the quality of data.

The analytical QC program is used to demonstrate that the ORSP is operating within prescribed requirements of accuracy and precision. These data are used in the preparation of control charts for each type of analysis and are appropriately evaluated. The QC samples are analyzed within the normal sample stream. Blind or known spiked samples are prepared at concentration levels which do not compromise the health and safety of laboratory personnel or cause deterioration of the low-level detection capability of counting equipment. The intralaboratory QC samples are summarized in Table 14.

A minimum of ten percent of the work load consists of QC samples. All of the various QC types are used where possible and practical for all analyses. If the sample is introduced by the QC Coordinator, the radionuclide content and activity are unknown to the technician. Samples unknown to the technician provide independent verification of laboratory operation.

The first line supervisor is responsible for QC programs and reporting results of the associated analyses to higher management. It is the responsibility of the Branch Chief to ensure that the laboratory performs the required analyses in a timely manner and that results are reported on time. The laboratory technician is responsible for the timely performance of the required analyses so that results may be reported on time. The technician is the primary person to make sure samples are processed quickly and tracked throughout the analysis process. The Branch Chief ensures that the first line supervisor and technicians receive proper training to perform their jobs with respect to QC activities in the best possible manner.

When applicable, method blanks for each analytical procedure are prepared. The blank is carried throughout the entire procedure. The blank is processed identically to the routine samples and counted accordingly. The QC program emphasizes blank control whenever blank correction is significant. Environmental control usually denotes good housekeeping practices, coupled with any special procedure used to minimize the potential for contamination. Contamination can arise from the following five principle sources:

- the analysis environment.
- the reagents used in the analysis.
- the apparatus used.
- radioactive decay products.
- the analyst performing the analysis.

Applicable SOPs are strictly followed so that contamination risk is minimized.

The first line supervisor is responsible for evaluating the stability and variability of the blank. Control charts for this parameter are used where applicable. If control charts are used, a review for trends and outliers is conducted on a routine basis. It might then be possible to correlate abnormalities with other experimental information to discover assignable causes and corrective measures necessary to obtain acceptable blanks. In general, however, an investigation is initiated whenever a blank is recorded that has a value greater than the expected lower limit of detection.

Duplicate samples are prepared where applicable. The sample is entered into the sample stream and analyzed in the exact manner as the regular samples for that particular type of analysis. Blind samples are prepared as needed (Table 14). The blind sample is entered into the sample stream and analyzed in the exact manner as the regular samples for that particular type of analysis. Blind sample data are evaluated on the basis of percent recovery and accuracy. Information on the efficiency, stability, and variability of recovery is evaluated by the first line supervisor. The application of a blind recovery correction factor is generally not merited. Table 15 shows the control limits for each type of analysis.

Matrix spikes are prepared by the first line supervisor or analyst/technician as needed (Table 14). These samples are entered into the sample stream and analyzed in the exact manner as the regular samples for that particular type of analysis. Matrix spike

TABLE 14. SUMMARY OF QUALITY CONTROL SAMPLES

ANALYSIS	MATRIX	FREQ. (% BLANK)	FREQ. (% DUP.)	FREQ. (% SPIKE)	FREQ. (% BLIND)
Kr	Air	4	4	1	1
Xe	Air	4	4	1	1
^{3}H	Air	4	3	2	1
^{3}H (Conventional)	Water	4	3	2	1
^{3}H (Enrichment)	Water	3	3	3	1
^{3}H	Urine	3	3	3	1
^{3}H	Tissue	4	4	1	1
^{89}Sr, ^{90}Sr	Milk	3	3	3	1
^{89}Sr, ^{90}Sr	Air Filter Composite	3	3	3	1
^{89}Sr, ^{90}Sr	Water	3	3	3	1
Pu Isotopes	(ANY)	3	3	3	1
U Isotopes	(ANY)	3	3	3	1
Th Isotopes	(ANY)	3	3	3	1
Gross Alpha/Gross Beta	Air Filters	3	10	2	1
Gross Alpha/Gross Beta	Water	3	3	3	1
Gamma Scan	Air Filters	3	10	1	1
Gamma Scan	Charcoal Cartridge	1	10	NA	1
Gamma Scan	Milk	8	10	3	1
Gamma Scan	Water	8	10	3	1

NA = not applicable

TABLE 15. BLIND CONTROL LIMITS

ANALYSIS	MATRIX	CONTROL LIMIT (±%)
Noble Gas	Air	20
^{3}H	Air	10
^{3}H (Conventional)	Water	10
^{3}H (Enrichment)	Water	20
^{3}H	Urine	10
^{3}H	Tissue	10
^{89}Sr, ^{89}Sr	Milk	10
^{89}Sr, ^{90}Sr Composite	Air Filter	20
^{89}Sr, ^{90}Sr	Water	20
Pu Isotopes	(ANY)	20
U Isotopes	(ANY)	10
Th Isotopes	(ANY)	10
Gross Alpha/Gross Beta	Air Filters	10
Gross Alpha/Gross Beta	Water	20
Gamma Scan	Air Filters	20
Gamma Scan	Charcoal Cartridge	20
Gamma Scan	Milk	20
Gamma Scan	Water	20

sample data are evaluated on the basis of percent recovery. Efficiency, stability, and variability of recovery are evaluated by the first line supervisor. The application of a matrix spike recovery factor is generally not merited. Table 16 shows the control limits for each type of analysis.

Control charts are basic tools for QA in the radioanalytical laboratory. They provide a graphical means to demonstrate statistical control, monitor a measurement process, diagnose measurement problems, document measurement uncertainty, identify and diagnose instrumental problems, and generally aid in methodology development. Background control charts are used for controlling the system background of counting instrumentation and determining possible contamination and/or trends. Technicians are responsible for counting, on a daily basis (or before each use), the background for the standard counting time (the time for which samples are normally counted). This value is recorded in the controlled notebook that is issued for this purpose. This value is also plotted on the control chart established for the specific system. Technicians are responsible for counting, on a daily basis (or before each use), a standard check source. These check sources are counted for a predetermined length of time. The technician records this value in a controlled notebook especially designated for this purpose. The notebook is kept near the instrument. This value is also plotted on a control chart established for a specific system.

Assuming that the data are normally distributed, a standardized statistic is computed and the resulting value plotted on a scatterplot with Mean=0, upper working level (UWL)=+2 S.D., upper control limit (UCL)=+3 S.D., lower working level (LWL)=–2 S.D., and lower control limit (LCL) =–3 S.D. Normalized deviation values falling outside the UCL and LCL (± 3 sigma) indicate "outlier" data values. Need for corrective action is indicated by 2–sigma and 3–sigma values. Some indicators of an "out-of-control" situation include:

- One point outside of the UCL or LCL.
- Two out of three consecutive points beyond the UWL or LWL.
- Eight consecutive points on one side of the center line.
- Any other systematic trend.

When an out-of-control situation arises, the analyst is instructed to recount the check source a minimum of five times to see if there really is a problem, or if the outlier was due to randomness (rare events). If a problem is indicated, the first line supervisor is notified of the condition, and appropriate diagnosis/correction of the problem is made. The first line supervisor is responsible for reviewing QC results produced by employees on a routine basis.

TABLE 16. MATRIX SPIKE CONTROL LIMITS

ANALYSIS	MATRIX	CONTROL LIMIT (±%)
Noble Gas	Air	20
^{3}H	Air	10
^{3}H (Conventional)	Water	10
^{3}H (Enrichment)	Water	20
^{3}H	Urine	10
^{3}H	Tissue	10
^{89}Sr, ^{89}Sr	Milk	20
^{89}Sr, ^{90}Sr Composite	Air Filter	20
^{89}Sr, ^{90}Sr	Water	20
Pu Isotopes	(ANY)	10
U Isotopes	(ANY)	10
Th Isotopes	(ANY)	10
Gross Alpha/Gross Beta	Air Filters	20
Gross Alpha/Gross Beta	Water	20
Gamma Scan	Air Filters	20
Gamma Scan	Charcoal Cartridge	20
Gamma Scan	Milk	20
Gamma Scan	Water	20

Quality assurance review is performed on all QC samples using the following procedure:

- Review the following sample paperwork: sample header card, analytical data sheets, QC sample data, sample tracking data management system (STDMS) data reports, requirements, and non-conformances, as applicable.
- Cross-check all information included for correctness and completeness of the data.
- Evaluate the QC results according to the control limits given in the applicable SOP.
- If a QC result is outside of the acceptable limits, the supervisor investigates the problem and determines the impact on other analytical results. Processing of samples is stopped, if necessary, until the problem is resolved.
- If QC results are acceptable, the supervisor signs and dates the listing.

6.3 DATA QUALITY OBJECTIVES

The EPA requires all projects involving environmentally related measurements to develop DQOs. These DQOs must clearly define the level of uncertainty that a decision maker is willing to accept in results derived from environmental data (SCB89).

The ORSP has always been operated with DQOs specified, but they are imbedded in various documents prepared by EPA and by DOE. In 1987, formal DQOs were developed and the necessary information was compiled as set forth below so that the DQOs are available as a single document. As a historical note, radiological monitoring activities have been in the forefront for developing data of known quality by applying the basic principles of what is now called QA/QC, and the ORSP always has had the objective of maintaining the radiochemical methods and instrumentation at state-of-the-art levels. In what follows, the essential elements listed in the Quality Assurance Management Staff (QAMS) document "Development of Data Quality Objectives" are addressed.

6.3.1 Data Quality Objectives for the Offsite Radiological Safety Program

Measurements of the volume of air, water, and milk samples must be accurate within ±10%. The results of gamma spectrometric analyses must be accurate with no more than a five percent risk of either a false positive or a false negative report.

Radiochemical analyses must have an uncertainty no greater than ±60% for results near the MDC and no greater than ±10% for results that are ten times the MDC.

The calculation of effective dose equivalents based on all environmental measurements must have an uncertainty no greater than ±50% for annual exposures between one and five mrem per year and no greater than ±10% for annual exposures at five mrem per year or more.

6.3.2 Decisions to be Made

In connection with nuclear weapons tests at the NTS, there are two decisions to be made, namely:

- Are radiation exposures to the offsite public from routine operations at the NTS within the radiation exposure standards set by the ICRP?

- Do radiation exposures of the offsite public from accidental releases of radioactivity from the NTS exceed the protective Action Guides published by the FDA or the maximum exposure level recommended by the ICRP?

The standards addressed by these decisions are at several reference levels, specified by DOE, in "Requirements for Radiological Effluent Monitoring and Environmental Surveillance for DOE Operations" (DOE91). They are:

- All pathways that lead to the following exposures shall be routinely monitored:

  a. One mrem annual effective dose equivalent to any offsite individual, or
  b. One hundred person-rem annual collective effective dose equivalent per million individuals within 80 km of the site center, or
  c. Five mrem annual whole-body dose equivalent or 15 mrem to the skin of offsite individuals.

- Any exposure to an offsite person of 25 mrem effective dose equivalent in any year shall be reported to DOE Headquarters.

- Unplanned releases of radioactivity shall be monitored and quantified.

- All measurements shall be based on statistically significant differences between the point of measurement and the background in the area or suitable control data.

6.3.3 Use of Environmental Data

Environmental data are needed so that the pathways for human exposure to radioactivity can be assessed for their contribution to total exposure. The pathways to be assessed include inhalation, ingestion, and direct radiation so air, water, milk, meat, and vegetables as well as external exposures due to penetrating radiation must be measured.

These measurements together with appropriate models and correction factors can be summed to give an effective dose equivalent for an individual or a critical population. The effective dose equivalent can then be compared with the criteria stated above to estimate the degree of compliance with those criteria.

6.3.4 Time and Resources Required

The resources to be used in collecting the pertinent environmental data are negotiated annually. Modifications to the sampling and QA programs may be incorporated as warranted by analysis of long-term trends and resource constraints. Such modifications may include changes in the number of sampling stations, media represented, radionuclides analyzed, or frequency of sample collection.

6.3.5 Description of Data to be Collected

The data to be collected are the average annual exposures contributed by each pathway to an individual (Table 17). For the inhalation pathway, air samples must be collected in such a manner that the average annual concentration of radioactive particulates, reactive gases, and tritium can be calculated.

For the ingestion pathway, the concentrations of radionuclides in water, milk, meat, and vegetables must be measured. The radioisotopes of concern include those of hydrogen, strontium, cesium, and iodine. The capability to detect other radionuclides must be available.

For the external exposure, measurement of penetrating radiation exposure of individuals and locations which are above natural background must be made. Whole body and skin exposure can also result from atmospheric concentrations of radioactive noble gases, so the average annual concentrations of those species must also be measured.

TABLE 17. SUMMARY OF ANNUAL EFFECTIVE DOSE EQUIVALENTS

SOURCE	RECIPIENT	ANNUAL EFFECTIVE DOSE EQUIVALENT mrem	mSv
For routine operations, including controlled releases (tunnel purgings and drillbacks):			
All (Air pathway)	Offsite person	10	0.1
For accidental releases of radioactivity:			
All	Offsite person	500	5*

**Permissible for few years if lifetime average does not exceed 100 mrem per year.*

6.3.6 Domain of the Decision

The environmental data on which a decision regarding compliance is to be made are collected in the area from the boundary of the NTS out to 180 miles (300 km) from that boundary, although DOE requires only the inclusion of all population centers within 48 miles (80 km) of the NTS. Where public concern is evident, suitable environmental monitoring should be extended as far as is feasible given the equipment and manpower available.

6.3.7 Calculations to be Performed on the Data

For air, water, milk, and food samples, any activity above the MDC is considered as contributing to exposure. The MDC is calculated from the formula:

$$MDC = 3.29KS$$

Where K is the proportionality constant relating detector response to the activity concentration in the sample, S is the estimated standard error for the net sample activity, and 3.29 is the factor used when both Type I and Type II errors (α and β) are set at 5 percent. For reporting purposes, the actual result obtained is used in the calculation of concentration averages even if that result is less than the MDC so that exposure values over time or space can be estimated.

The external exposure data as measured by TLDs are compared with environmental background data for each area. The background data are the average and standard deviation obtained for the previous four quarters at a given location. For personnel exposures, the data from the personnel TLDs are also compared with the area background to determine any net exposure. The data from both the area and the personnel TLDs are compared with the background data using an analysis of variance to determine whether any statistically valid difference exists.

In the case of atmospheric emissions from the NTS as reported by DOE, a Gaussian plume dispersion model and the EPA AIRDOSE/RADRISK code are used to calculate exposure to offsite individuals. Effective dose equivalents from inhalation and ingestion of radionuclides are calculated using the methods in ICRP report 26 with the dose conversion factors given in ICRP report 30 (ICRP79).

Data quality objectives contain quantitative statements relating to the decision to be made, how environmental measurements are to be used, time and resource constraints on data collection, descriptions of the data or measurements to be made, specifications of which portions of the physical systems from which samples will be collected, and the calculations that are to be performed on the data in order to arrive at a result.

6.4 DATA VALIDATION

An essential element of QA is the validation of data. Four categories of data validation methods are employed in the ORSP: procedures applied routinely to ensure adherence of acceptable analytical methods; those that ensure that completeness of data is attained; those that are used to test the internal comparability within a given data set; and procedures for comparing data sets with historical data and other data sets.

Completeness is the amount of data successfully collected with respect to that amount intended in the design, and comparability refers to the degree of similarity of data from different sources included in a single data set. All data are reviewed by supervisory personnel to ensure that sufficient data have been

collected and the conclusions are based upon valid data. Completeness is an important part of quality, since missing data may reduce the precision of estimates, introduce bias, and thus lower the level of confidence in the conclusions.

6.4.1 Box-and-Whisker Plots

The box-and-whisker plot, commonly called box plot, is an effective way to display summary statistics graphically (VEL 81). It allows for the detection of outliers and of asymmetric behavior (shows little or no correspondence of form on opposite side of a boundary) of a data set. As shown in Figure 43, the plot divides the data into four equal areas, or "quartiles." The "box" contains two quartiles, each containing 25 percent of the data, and the two "whiskers" each contain one quartile (25%).

The range of the data (the difference between the highest and lowest values), the median (the middle value), and whether or not the data is skewed (shifted, i.e., indicated when one "whisker" is longer than the other) can easily be determined. The box itself covers the middle 50 percent of the data values. Variability of the data is also indicated by the height of the box, as well as by whisker length.

When unusual values occur far away from the bulk of the data, they are plotted as separate points. The whiskers extend only to those points that are within 1.5 times the range (the difference between the highest and lowest values) of the box. Values outside the whiskers denoted by an "*" are possible outliers. They are between 1.5 and 3 times the range of the box. Values denoted by an "O" are very far out of range (at least 3 times the box range) and are probable outliers.

There are several possible causes of outliers or asymmetric behavior of the data:

- Random fluctuations.
- NTS emissions of radionuclides.
- Non-NTS emissions of radionuclides.

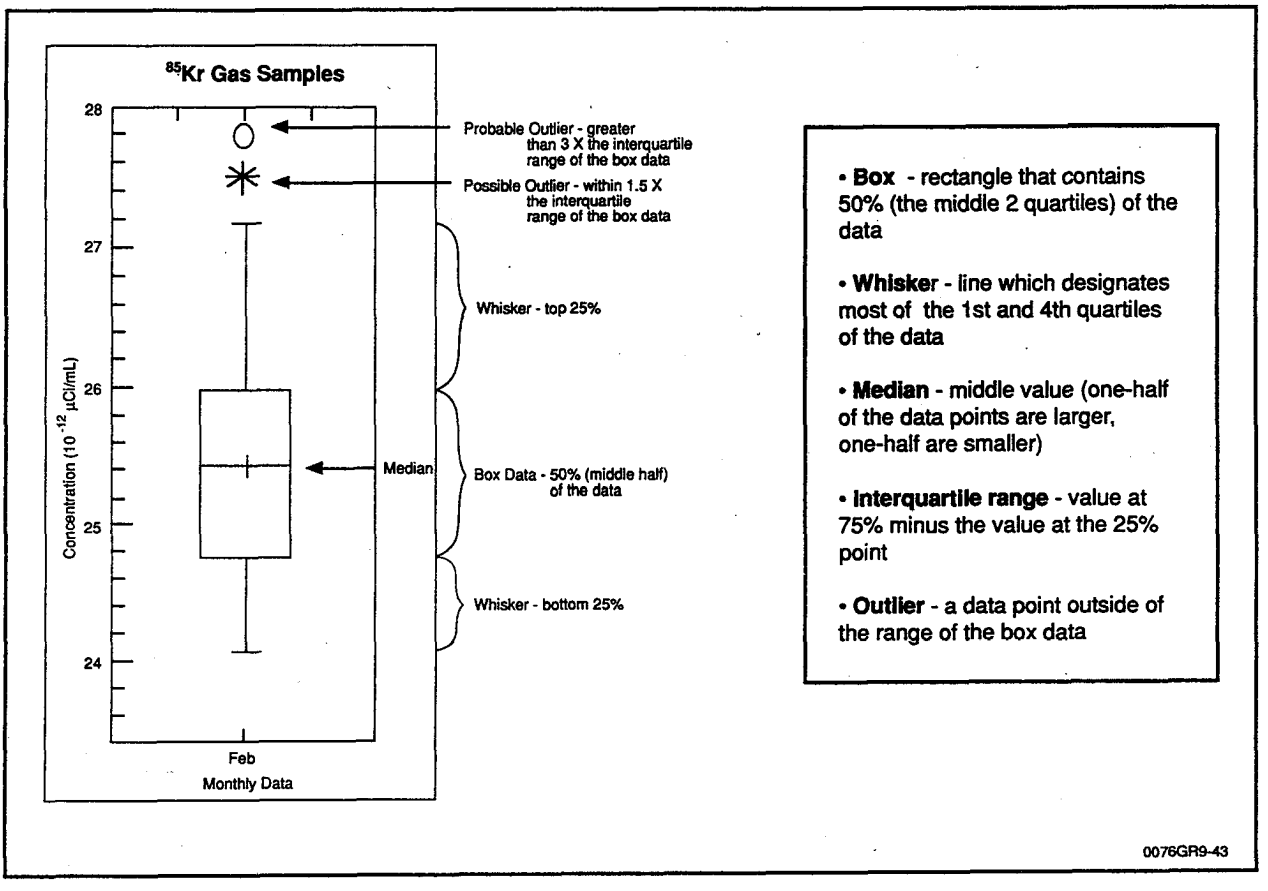

Figure 43. Example of a box-and-whisker plot (VEL 81).

The box-and-whisker plot allows for closer examination of the data to determine the reason for unusual or out of range data. Box-and-whisker plots are used as a tool in the validation of data for most networks. Plots of this type can be found in the Appendix.

6.5 QUALITY CONTROL

The QC portion of the ORSP QA program consists of routine use of methods and procedures designed to achieve and maintain the specified level of quality for the given measurement system. Accuracy of analysis is achieved through the regular determination of bias and precision of the results.

Bias is defined as the difference between the data set mean value (or sample average for statistical purposes) and the true or reference value (EPA87). The EPA EMSL-LV laboratory participates in EPA, DOE/ Environmental Measurements Laboratory (EML), and World Health Organization laboratory intercomparison crosscheck studies. The results of the EPA intercomparison study are discussed later in this section. Blank samples and samples spiked with known quantities of radionuclides are also routinely analyzed. Internal blind spiked samples, (i.e., samples spiked with known amounts of radionuclides but unknown to the analyst) are also entered into the normal chain of analysis.

Precision is the degree of mutual agreement among individual measurements made under prescribed conditions (EPA87). At a minimum, three percent of all samples are collected and analyzed in duplicate, and results compared. In addition, instruments are calibrated with standards directly or indirectly traceable to NIST (formerly National Bureau of Standards) or approved EPA-generated sources. Performance checks are routinely accomplished, control charts of background and check source data are maintained, and preventive maintenance of equipment is scheduled and performed.

6.5.1 Milk Surveillance Network

Samples are collected from established locations using documented SOPs. Milk samples are delivered to sample control by field monitoring personnel or by the U.S. Postal Service. Samples are accompanied by a sampling report, a sample collection tag, and a chain-of-custody form. Upon receipt, milk samples are assigned a unique identification number and the information from the sampling report is keyed into STDMS and a header sheet is generated.

For gamma analysis, 3.5-kg samples are weighed into labelled Marinelli beakers. Sample size is verified by calibration of the balance using NIST-certified weights. An accuracy of within five percent meets the DQOs. Gamma spectrometers are efficiency calibrated using NIST mixed radionuclide sources prepared in the same geometry and matrix as the milk samples. Analysis is performed with vendor-supplied software to calculate and store an efficiency vs. energy curve. A daily performance check is completed and control charts are prepared using QA software. Analysis of results is accomplished using vendor-supplied software. Results are reviewed by a gamma spectroscopist and the data are entered into STDMS. Samples are reanalyzed as duplicates (replicates) on a routine basis. A minimum of ten percent of all samples are QA samples (i.e., blanks, duplicates, spikes, and blinds). The blind control limit and the matrix spike control limit are ±10% and ±20%, respectively.

Aliquots for radiochemical analysis of the radiostrontiums also have sample control procedures as outlined above. Spiked samples are prepared from NIST-traceable materials. Blank, duplicate, spiked, and blind samples are incorporated at the frequencies shown in Table 14. Samples are analyzed within three months of collection. Results must be accurate within ±20%. Balances are calibrated annually by the vendor and the gas flow counter is calibrated annually using NIST-traceable standards. Control charts of standards and backgrounds are maintained. If any samples remain after analysis, they are returned to sample control according to chain-of-custody procedures and are stored in a cooler for six months.

6.5.2 Internal Dosimetry Program

Bioassay of urine samples for tritium follows sample control procedures similar to that for milk. A minimum of ten percent of the samples are QC samples. Three percent (each) of the samples are blanks, duplicates, and spikes, and one percent are blind, as indicated in Table 14. The procedure is accurate within ten percent as measured with NIST-traceable spiked samples. The liquid scintillation counter is calibrated with NIST-traceable standards as part of the maintenance contract. Sealed standard and backgrounds are used for performance checks and control charts are maintained.

All data are entered into the STDMS data base and reviewed for transcription errors and for anomalous

results. Data entered into the permanent data base may occasionally need to be corrected to preserve the integrity of the data base. To document corrections, a data correction form must be prepared and approved by two persons before being submitted for inclusion. All data are reviewed by a health physicist for completeness and comparability, trends are identified, and potential risks to humans and the environment are determined based on the data.

The whole-body detector is efficiency calibrated annually using a Bottle Mannequin Absorber (BOMAB) phantom containing a NIST-traceable mixed radionuclide source. The lung counter is also calibrated annually with a male realistic lung phantom. A separate set of efficiency calibration data is kept for each combination of sample shape/organ geometry.

All efficiency curves are generated by the vendor-supplied whole-body counting and lung-counting software. Daily performance and background routines are completed and QA software is used to monitor the systems by performing out-of-range tests for predetermined parameters. Results are plotted and reports generated daily and monthly. All data are stored in the computer. Determination of precision is limited by the sample, i.e., human being. Replicate counting of the standard BOMAB phantom provides a measure of consistency. Replicate counts of blind intercalibration phantoms and of people counted previously in other facilities provide additional measurements of precision and accuracy. Verification and validation are completed before results are entered into a data base. Calculation of internal dose is done utilizing software based on the ICRP-30 methodology (ICRP79). Dose calculation is verified using ICRP and National Council of Radiation Protection and Measurement (NCRP) guidelines (NCRP89). Preventive maintenance and repair of analytical equipment are done by the vendor service representative. Data are retained permanently. Subject confidentiality and data security are maintained through well-established procedures. Whole body counting personnel participate in DOE and EPA QA training programs.

6.5.3 Pressurized Ion Chamber Network

External ambient gamma exposure rate measurements made by the PICs are validated by calibrating annually. Weekly checks are made using sealed radioactive sources of known activity. Data and calibration checks are evaluated weekly to detect trends or anomalies.

6.5.4 Thermoluminescent Dosimeter Network

The TLD program is fully accredited by DOELAP. In addition, environmental TLD monitoring is conducted in accordance with ANSI. The thermoluminescent dosimetry system is calibrated semiannually. Transit controls, irradiated controls, and unirradiated background dosimeters are used to verify proper reader performance and to correct for background exposure occurring during other than the deployment period. Regular cleaning and maintenance of the Panasonic TLD readers helps prevent mechanical failure.

6.6 HEALTH PHYSICS OVERSIGHT

All analytical results receive a final review by EPA health physics personnel for completeness and comparability. Increasing or decreasing trends of radionuclides in the environment are identified and potential risks to humans and the environment are determined based on the data.

6.7 PRECISION OF ANALYSIS

The duplicate sampling program was initiated for the purpose of routinely assessing the errors due to sampling, analysis, and counting of samples obtained from the surveillance networks maintained by EMSL-LV. The program consists of analyzing duplicate or replicate samples from the ASN, NGTSN, MSN, TLD, and LTHMP networks. As the radioactivity concentration in samples collected from the LTHMP and the MSN are usually below detection levels, most duplicate samples for these networks are prepared from spiked solutions. The noble gas samples are generally split for analysis and duplicate samples are collected in the ASN. Since two TLD cards consisting of three TLD phosphors each are used at each fixed environmental station in the TLD network, no additional replicate samples are necessary.

At least 30 duplicate samples from each network are normally collected and analyzed over the report period. The standard deviation is obtained by taking the square root of the variance. Table 18 summarizes the sampling information for each surveillance network.

TABLE 18. SAMPLES AND ANALYSES FOR DUPLICATE SAMPLING PROGRAM — 1990

SURVEILLANCE NETWORK	NUMBERS OF SAMPLING LOCATIONS	SAMPLES COLLECTED THIS YEAR	DUPLICATE SAMPLES COLLECTED	SAMPLE ANALYSIS
ASN	110	2,020	118	Gross beta, γ Spectrometry $^{238,239+240}Pu$
NGTSN	19	837 (^{85}Kr)	-	^{85}Kr, ^{133}Xe
		837 (^{133}Xe)	-	
		1,003 (HTO)	4	HTO
Dosimetry	133	610	610	Effective dose from gamma
MSN	132	403	100	^{40}K, ^{89}Sr, ^{3}H
LTHMP	265	1,089	379	^{3}H

The variance, s^2, of each set of replicate results is estimated by the standard expression (SNE67):

$$s^2 = \sum_{i=1}^{n} (x_i - \bar{x})^2 / (n-1) \qquad \text{Eq. 1}$$

where n = number of replicates.

The principle that the variances of random samples collected from a normal population follow a chi-square distribution (X^2) is then used to estimate the expected population standard deviation for *each type of sample analysis*. The expression used is as follows (FRE62):

$$s = \sqrt{\sum_{i=1}^{k} (n_i - 1)\, s_i^2 \Big/ \sum_{i=1}^{k} (n_i - 1)} \qquad \text{Eq. 2}$$

where $n_i - 1$ = the degrees of freedom for n_i samples collected for the ith set.

k = number of sets.

s_i^2 = the expected variance of the ith replicate sample.

s = the pooled estimate of sample standard deviation derived from the variance estimates of all replicate samples (the expected value of s^2).

For expressing the precision of measurement in common units, the coefficient of variation ($s/\bar{x}$) is calculated for each sample type (NEL75). These are displayed in Table 21 for those analyses for which there were adequate data.

To estimate the precision of counting, approximately ten percent of all samples are counted twice. These are unknown to the analyst. Since all such replicate counting gave results within the counting error, the precision data in Table 19 represent total error in sampling and analysis.

6.8 ACCURACY OF ANALYSIS

Data from the analysis of intercomparison samples are statistically analyzed and compared to known values and values obtained from other participating laboratories. A summary of the results is given in Table 20, which compares the mean of three replicate analyses with the known value. The normalized deviation is a measure of the accuracy of the analysis when compared to the known concentration. The determination of this parameter is explained in detail in the reference (JA81). If the value of this parameter (in multiples of standard normal deviate, unitless)

TABLE 19. SAMPLING AND ANALYTICAL PRECISION — 1990

SURVEILLANCE NETWORK	ANALYSIS	SETS OF REPLICATE SAMPLES EVALUATED	COEFFICIENT OF VARIATION (%)
ASN	Gross Beta	216	9
NGTSN	^{85}Kr	46	8
TLD	Gamma	663	22.4
MSN	^{90}Sr	15	1.3
	^{3}H	44	0.5
LTHMP	^{3}H	44	4.1*
	^{3}H+(enriched tritium)	23	17*

* *True mean*

lies between control limits of –3 and +3, the precision or accuracy of the analysis is within normal statistical variation. However, if the parameters exceed these limits, one must suspect that there is something other than normal statistical variation that contributed to the difference between the measured values and the known value.

The analytical methods are further validated by laboratory participation in the semiannual DOE QA Program conducted by the EML, New York, NY. The 1990 results from these tests (Table 20 and Table A9 in the Appendix) indicate that the EPA EMSL-LV laboratory results were of acceptable quality in that the DQOs for accuracy of radiochemical analyses given in Section 6.3.1 were met or exceeded for most radionuclides as indicated by the ratios.

6.9 QUALITY ASSESSMENT FOR BIOMONITORING PROGRAM

To measure the performance of the contractor laboratory that analyzed the animal tissues, a known amount of activity was added to several sets of bone ash samples. The reported activity is compared to the known amount in bone ash in Table A10 (Appendix). The percent bias for the spiked samples was determined by subtracting 100 from the average percent of activity recovered. As the contractor laboratory had difficulty recovering strontium in two shipments, a special shipment of four spiked bone ash samples was provided in April 1991. The average bias for ^{90}Sr, including these four samples plus all valid routine samples, was 61 percent. The average bias for $^{239+240}Pu$ was two percent, based on two sample analyses. Precision was determined by calculating the coefficient of variation for each pair of values and then averaging. The average precision determined from two sets of duplicate bone samples was 70 percent for $^{239+240}Pu$ and 11 percent for ^{90}Sr. The average precision for three sets of liver samples was 23 percent for $^{239+240}Pu$. The DQO for uncertainty in results less than ten times the MDC is 60%. This DQO was met with the exception of $^{239+240}Pu$ in bone samples. However, overall precision was calculated using results less than the MDC, for which precision is undefined.

TABLE 20. QUALITY ASSURANCE RESULTS FROM DEPARTMENT OF ENERGY PROGRAM — 1990

ANALYSIS	MONTH	EPA EMSL-LV RESULTS	EML RESULTS	RATIO EPA/EML	ANALYSIS	MONTH	EPA EMSL-LV RESULTS	EML RESULTS	RATIO EPA/EML
^{54}MN in air	Sept.	41.9	33.3	1.26	^{54}Mn in water	Sept.	302	301	1.00
^{57}Co in air	Sept.	15.1	11.4	1.32	^{57}Co in water	Sept.	1350	1300	1.04
^{60}Co in air	Sept.	28.1	25.4	1.11	^{60}Co in water	Sept.	503	491	1.02
^{90}Sr in air	Sept.	0.100	0.093	1.08	^{90}Sr in water	Sept.	9.00	9.93	0.91
^{134}Cs in air	Sept.	20.7	16.3	1.27	^{134}Cs in water	Sept.	372	355	1.05
^{137}Cs in air	Sept.	19.6	15.7	1.25	^{137}Cs in water	Sept.	403	390	1.03
^{144}Ce in air	Sept.	20.9	16.5	1.27	^{144}Ce in water	Sept.	908	923	0.98
$^{239+240}$Pu in air	Sept.	0.0467	0.0510	0.92	$^{239+240}$Pu in water	Sept.	0.857	1.09	0.79
^{3}H in water	Sept.	4430	3900	1.14	Total U	Sept.	0.527	0.480	1.10

EPA EMSL-LV = U.S. Environmental Protection Agency Environmental Monitoring Systems Laboratory, Las Vegas.
EML = Environmental Monitoring Laboratory.

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7 Dose Assessment

W. G. Phillips

The extensive offsite environmental surveillance system operated around the NTS by EPA EMSL-LV measured no radiological exposures that could be attributed to recent NTS operations. Calculation of potential dose to offsite residents, based on onsite source emission measurements provided by DOE and calculated by EPA's AIRDOS–PC model, resulted in a maximum calculated dose of 6×10^{-3} mrem (6×10^{-5} mSv) to a hypothetical resident of Crystal, NV, 31 miles (52 km) south of the NTS CP-1. Monitoring network data indicated a 1990 dose of 123 mrem from normal background radiation occurring at Crystal. The calculated population dose to the approximately 7,700 residents living within 48 miles (80 km) of CP–1 was 1.5×10^{-2} person-rem (1.5×10^{-4} person-sievert).

7.1 ESTIMATED DOSE FROM NEVADA TEST SITE ACTIVITIES

The estimated effective dose equivalent to the offsite population due to NTS activities was based on the total release of radioactivity from the NTS in 1990 as listed in Table 2. As no radioactivity of recent NTS origin was detectable offsite by the various monitoring networks, no measurable exposure to the population living around the NTS was expected. To confirm this expectation, a calculation of estimated dose was performed using EPA's AIRDOS–PC model. The individuals exposed were considered to be all of those living within a radius of 48 miles (80 km) of the NTS CP–1, a total of 7,700 individuals. The hypothetical individual with the maximum calculated dose from airborne NTS radioactivity would have been continuously present at Crystal, NV, 31 miles (52 km) south of CP–1. That maximum dose was 6×10^{-3} mrem (6×10^{-5} mSv). The population dose within 80 kilometers from airborne emissions was calculated to be 1.5×10^{-2} person-rem (1.5×10^{-4} person-Sv).

During calendar year 1990, there were four sources of possible radiation exposure to the population of Nevada that were measured by the offsite monitoring networks. The four sources were:

- Operational releases of radioactivity from the NTS, including those from drillback and purging activities.
- Radioactivity that was accumulated in migratory game animals during their residence on the NTS.
- Worldwide distributions, such as ^{90}Sr in milk and ^{85}Kr in air.
- Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and ^{7}Be in air.

The estimated dose equivalent exposures from these sources to persons living near the NTS are calculated separately in the following subsections. Table 21 summarizes the annual effective dose equivalents due to operations at the NTS during 1990 using AIRDOS–PC and the released radionuclides listed in Table 2.

7.2 ESTIMATED DOSE FROM WORLDWIDE FALLOUT

From the monitoring networks described in previous chapters of this report, the following concentrations of radioactivity were found:

- ^{3}H; 6×10^{-7} μCi/m³ of air (2.2×10^{-2} Bq/m³).
- ^{85}Kr; 26 pCi/m³ of air (1 Bq/m³).
- ^{90}Sr; 6×10^{-7} μCi/L in milk (2.2×10^{-2} Bq/L).
- ^{137}Cs; 38 pCi/kg in deer kidney (1.4 Bq/kg).
- $^{239+240}Pu$; 0.201 pCi/kg (7×10^{-3} Bq/kg) in beef liver and 0.102 pCi/kg (4×10^{-3} Bq/kg) in deer meat.

The dose is estimated from these findings by using the assumptions and dose conversion factors as follows:

- Adult breathing rate is 8400 m³/yr.
- Milk intake (for a ten-year old) is 160 L/year.

TABLE 21. SUMMARY OF ANNUAL EFFECTIVE DOSE EQUIVALENTS FROM NEVADA TEST SITE OPERATIONS DURING 1990

	MAXIMUM DOSE AT NTS BOUNDARY[a]	MAXIMUM DOSE TO AN INDIVIDUAL[b]	COLLECTIVE DOSE TO POPULATION WITHIN 80 km of NTS CP–1
Dose	8.9×10^{-3} mrem (8.9×10^{-5} mSv)	$6.0 \pm 0.6 \times 10^{-3}$ mrem (6.0×10^{-5} mSv)	1.5×10^{-2} person-rem (1.5×10^{-4} person-Sv)
Location	Site boundary 30 km south of NTS CP–1 at 191°	Crystal, Nevada, 52 km south of NTS CP–1	7700 people within 80 km of NTS CP–1
NESHAP Standard	----	10 mrem per year (0.1 mSv per yr)	----
Percentage of NESHAP	----	6.0×10^{-2}	----
Background	123 ± 5.3 mrem (1.2 mSv)	123 ± 5.3 mrem (1.2 mSv)	759 person-rem (7.9 person–Sv)
Percentage of Background	7.2×10^{-3} %	4.9×10^{-3} %	2×10^{-3} %

[a] *The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the Nevada Test Site (NTS) boundary located 30 km from Control Point-1 (CP–1) in the direction 191° south.*

[b] *The maximum individual dose is to an individual outside the NTS boundary at a residence where the highest dose-rate occurs as calculated by AIRDOS–PC (Version 3.0) using NTS effluents listed in Table 2 and assuming all tritiated water input to containment ponds was evaporated.*

- Consumption of beef liver is 0.5 lb/wk (11.5 kg/yr).
- An average deer has 100 lb (45 kg) of meat.

The dose conversion factors are derived from Appendix C of NCRP Commentary No. 3 (NCRP89). These are:

- ^{3}H; 1.3×10^{-7} mrem/pCi.
- ^{90}Sr; 1.3×10^{-4} mrem/pCi.
- ^{137}Cs; 4.6×10^{-5} mrem/pCi.
- ^{85}Kr; 1.1×10^{-5} mrem/yr per pCi/m^3.
- $^{239+240}Pu$; 9×10^{-4} mrem/pCi.

As an example calculation, the following is the result for ^{3}H exposure from breathing HTO:

- 0.6 pCi/m^3 x 8400 m^3/yr x (1.3×10^{-7} mrem/pCi) = 6.6×10^{-4} mrem/yr. However, in calculating the inhalation dose from ^{3}H, the value is always doubled to account for absorption through the skin. The total dose, therefore, is 1.2×10^{-3} mrem/yr.

Also:

- 0.6 pCi/L x 160 L/yr x (1.3×10^{-4} mrem/pCi) = 0.012 mrem/yr.
- ^{85}Kr; 26 pCi/m^3 x (1.1×10^{-5} mrem/year per pCi/m^3) = 3×10^{-4} mrem/yr.
- $^{239+240}Pu$; 0.201 pCi/kg x 11.8 kg/yr x (9×10^{-4} mrem/pCi) = 2.1×10^{-3} mrem/yr.

Therefore, exposure to worldwide fallout causes a dose equivalent equal to the sum of the four preceding exposures or approximately 1.5×10^{-2} mrem (1.5×10^{-4} mSv).

7.3 ESTIMATED DOSE FROM RADIOACTIVITY IN A NEVADA TEST SITE DEER

The highest measured concentrations of radionuclides in deer tissues occurred in deer collected on the NTS. There was 38 pCi/kg of ^{137}Cs in a kidney sample and 0.1 pCi/kg of $^{239+240}Pu$ in a muscle sample.

In the unlikely event that one such deer was collected by a hunter in offsite areas, the hunter's intake could be calculated. Assuming two pounds (0.9 kg) of

kidney and 100 pounds (45 kg) of meat with the radionuclide concentrations listed above, the dose equivalent would be:

- 38 pCi/kg x 0.9 kg x (4.6×10^{-5} mrem/pCi) = 1.6×10^{-3} mrem.
- 0.1 pCi/kg x 45 kg x (9×10^{-4} mrem/pCi) = 4×10^{-3} mrem.

Thus, approximately 6 μrem (6×10^{-5} mSv) would be delivered to one individual consuming the stated quantity of meat and assuming no radioactivity was lost in food preparation.

7.4 DOSE FROM BACKGROUND RADIATION

In addition to external radiation exposure due to cosmic rays and gamma radiation from naturally occurring radionuclides in soil (e.g., ^{40}K, uranium and thorium daughters), there is a contribution from ^{7}Be that is formed in the atmosphere by cosmic ray interactions with oxygen and nitrogen. The annual average ^{7}Be concentration measured by the offsite air surveillance network was 0.11 pCi/m^3. With a dose conversion factor for inhalation of 2.6×10^{-7} mrem/pCi, this equates to 2.4×10^{-4} mrem, a negligible quantity when compared with the PIC network measurements that vary from 50 to 170 mR/year, depending on location.

7.5 SUMMARY

The individual with the calculated (modeled) highest exposure to NTS effluent during 1990 was a hypothetical person living in Crystal, NV, where the NTS exposure, plus that due to worldwide fallout, plus background would total $(6 \times 10^{-3}) + (1.5 \times 10^{-2}) +$ 123 mrem ≅ 123 mrem (1.2 mSv). Both the NTS and worldwide distributions contribute a negligible amount of exposure compared to natural background. If one of these people was to collect and consume an NTS deer, that estimated dose equivalent would increase by 6×10^{-3} mrem, a negligible amount.

The 123 mrem figure is derived from average PIC field measurements of 14 μR/hr. The uncertainty (2σ) for this measurement at this exposure level is approximately 4.3%. Extrapolating to the calculated annual exposure at Crystal, NV, yields a total uncertainty of approximately 5.3 mrem. The estimated dose from NTS activities is much less than 1 mrem, the lowest level for which DQOs are defined, as given in Section 6.3.1. Therefore, no conclusions can be made regarding the achieved data quality as compared to the DQO.

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8 Sample Analysis Procedures

R. W. Holloway

The procedures for analyzing samples collected for this report are described in Johns et al. (EMSL79) and are summarized in Table 22. These include gamma analysis, gross beta on air filters, strontium, tritium, plutonium, and noble gas analyses. These procedures outline standard methods used to perform given analytical procedures.

TABLE 22. SUMMARY OF ANALYTICAL PROCEDURES

TYPE OF ANALYSIS	ANALYTICAL EQUIPMENT	COUNTING PERIOD (min)	ANALYTICAL PROCEDURES	SAMPLE SIZE	APPROXIMATE DETECTION LIMIT[a]
IG Ge(Li) Gamma[b]	IG or GE(Li) detector-calibrated at 0.5 keV/ channel (0.04 to 2 meV range) individual detector efficiencies ranging from 15 to 35%.	Air charcoal cartridges and individual air filters, 30; 100 for milk, water, suspended solids.	Radionuclide concentration quantified from gamma spectral data by online computer program. Radionuclides in air filter composite samples are identified only.	560 m^3 for air filters and charcoal cartridges; 3.5 L for milk and water.	For routine milk and water generally, 5 x 10^{-9} µCi/mL (1.85 x 10^{-1} Bq/L) for most common fallout radionuclides in a simple spectrum. Filters for LTHMP suspended solids, 6 x 10^{-9} µCi/mL (2.22 x 10^{-1} Bq/L). Air filters and charcoal cartridges, 0.04 x 10^{-12} µCi/mL (1.48 x 10^{-3} Bq/m^3).
Gross beta on air filters	Low-level end window, gas flow proportional counter with a 5-cm diameter window	30	Samples are counted after decay of naturally occurring radionuclides and, if necessary, extrapolated to midpoint of collection in accordance with $t^{-1.2}$ decay or an experimentally-derived decay.	560 m^3	2.5 x 10^{-15} µCi/mL (9.25 x 10^{-5} Bq/m^3)
$^{89+90}Sr$	Low background thin-window, gas-flow, proportional counter.	50	Chemical separation by ion exchange. Separated sample counted successively; activity calculated by simultaneous solution of equations.	1.0 L for milk or water. 0.1 to 1 kg for tissue.	^{89}Sr = 5 x 10^{-9} µCi/mL (1.85 x 10^{-1} Bq/L) ^{90}Sr = 2 x 10^{-9} µCi/mL (7.4 x 10^{-2} Bq/L)

(continued)

TABLE 22. (Continued)

TYPE OF ANALYSIS	ANALYTICAL EQUIPMENT	COUNTING PERIOD (min)	ANALYTICAL PROCEDURES	SAMPLE SIZE	APPROXIMATE DETECTION LIMIT[a]
^{3}H	Automatic liquid scintillation counter with output printer.	300	Sample prepared by distillation.	5 to 10 mL for water.	300 to 700 x 10^{-9} µCi/mL (11–26 Bq/L)[c]
^{3}H Enrichment (LTHMP samples)	Automatic liquid scintillation counter with output printer.	300	Sample concentrated by electrolysis followed by distillation.	250 mL for water.	10 x 10^{-9} µCi/mL (3.7 x 10^{-1} Bq/L)
$^{238,239+240}Pu$	Alpha spectrometer with silicon surface barrier detectors operated in vacuum chambers.	1,000	Water sample or acid-digested filter or tissue samples separated by ion exchange, electroplated on stainless steel planchet.	1.0 L for water; 0.1 to 1 kg for tissue; 5,000 to 10,000 m^3 for air.	^{238}Pu = 0.08 x 10^{-9} µCi/mL (2.9 x 10^{-3} Bq/L), $^{239+240}Pu$ = 0.04 x 10^{-9} µCi/mL (1.5 x 10^{-3} Bq/L) for water. For tissue samples, 0.04 pCi (1.5 x 10^{-3} Bq) per total sample for all isotopes; 5 x 10^{-17} to 10 x 10^{-17} µCi/mL (1.9 x 10^{-6} to 3.7 x 10^{-6} Bq/m^3) for plutonium on air filters.
^{85}Kr, ^{133}Xe, ^{135}Xe	Automatic liquid scintillation counter with output printer.	200	Separation by gas chromatography; dissolved in toluene "cocktail" for counting.	0.4 to 1.0 m^3 for air.	^{85}Kr, ^{133}Xe, ^{135}Xe = 4 x 10^{-12} µCi/mL (1.5 x 10^{-1} Bq/m^3)

[a] *The detection limit is defined as the smallest amount of radioactivity that can be reliably detected, i.e., probability of Type I and Type II error at 5 percent each (DOE81).*

[b] *Gamma spectrometry using either an intrinsic germanium (IG), or lithium-drifted germanium diode (Ge(Li)) detector.*

[c] *Depending on sample type.*

9 Radiation Protection Standards for External and Internal Exposure

N. R. Sunderland

Design and operation of the ORSP are based on requirements and guidelines contained in applicable legislation and literature. A summary of applicable regulations and guidelines follows.

9.1 DOSE EQUIVALENT COMMITMENT

For stochastic effects in members of the public, the following limits are used:

	EFFECTIVE DOSE mrem/yr	DOSE EQUIVALENT[a] mSv/yr
Occasional annual exposures[b]	500	5
Prolonged period of exposure	100	1

[a] *Includes both effective dose equivalent from external radiation and committed effective dose equivalent from ingested and inhaled radionuclides.*

[b] *Occasional exposure implies exposure over a few years with the provision that over a lifetime the average exposure does not exceed 100 mrem (1 mSv) per year (ICRP39).*

9.2 CONCENTRATION GUIDES

ICRP–30 lists Derived Air Concentrations (DAC) and Annual Limit on Intake (ALI)(ICRP79). The ALI is the secondary limit and can be used with assumed breathing rates and ingested volumes to calculate concentration guides. The concentration guides (CGs) in Table 23 were derived in this manner and yield the committed effective dose equivalent (50 year) of 100 mrem/yr for members of the public.

9.3 U.S. ENVIRONMENTAL PROTECTION AGENCY DRINKING WATER GUIDE

In 40 CFR 141 (CFR88), the EPA set allowable concentrations for continuous controlled releases of radionuclides to drinking water sources. Any single or combination of beta and gamma emitters should not lead to exposures exceeding 4 mrem/yr. For tritium, this is 2.0×10^{-5} μCi/mL (740 Bq/L) and for ^{90}Sr is 8×10^{-9} μCi/mL (0.3 Bq/L).

TABLE 23. ROUTINE MONITORING GUIDES

NUCLIDE	SAMPLING FREQUENCY	LOCATIONS	SAMPLE SIZE	COUNT TIME	CONCENTRATIONS GUIDE[a]		MDC	MDC (%CG)
Air Surveillance Network			m^3	Minutes	Bq/m^3	μCi/mL	mBq/m^3	
^{7}Be	1/wk	all	560	30	1700	4.7×10^{-8}	17	1×10^{-3}
^{95}Zr	1/wk	all	560	30	12	3×10^{-10}	4.1	4×10^{-2}
^{95}Nb	1/wk	all	560	30	110	3×10^{-9}	1.8	2×10^{-3}
^{99}Mo	1/wk	all	560	30	110	3×10^{-9}	1.5	2×10^{-3}
^{103}Ru	1/wk	all	560	30	58	1.5×10^{-9}	1.8	3×10^{-3}
^{131}I	1/wk	all	560	30	4	1×10^{-10}	1.8	4×10^{-2}
^{132}Te	1/wk	all	560	30	17	5×10^{-10}	1.8	1×10^{-2}
^{137}Cs	1/wk	all	560	30	12	3×10^{-10}	1.8	2×10^{-2}
^{140}Ba	1/wk	all	560	30	120	3×10^{-9}	4.8	4×10^{-3}

(continued)

TABLE 23. (Continued)

NUCLIDE	SAMPLING FREQUENCY	LOCATIONS	SAMPLE SIZE	COUNT TIME	CONCENTRATIONS GUIDE[a]		MDC	MDC (%CG)
Air Surveillance Network			m^3	Minutes	Bq/m^3	$\mu Ci/mL$	mBq/m^3	
^{140}La	1/wk	all	560	30	120	3×10^{-9}	2.6	2×10^{-3}
^{141}Ce	1/wk	all	560	30	52	1.4×10^{-9}	3.0	6×10^{-3}
^{144}Ce	1/wk	all	560	30	1.2	3×10^{-11}	12	1.0
^{238}Pu	1/mo	all	2400	1000	5×10^{-4}	1×10^{-14}	1.5×10^{-3}	0.32
Gross Beta	1/wk	all	560	30	2×10^{-2}	5×10^{-13}	0.11	6×10^{-1}
^{3}H	1/wk	19	5	150	4.6×10^{3}	1.2×10^{-7}	148	3×10^{-3}
^{85}Kr	1/wk	16	0.4	200	2.2×10^{4}	6.2×10^{-7}	148	6×10^{-4}
^{133}Xe	1/wk	16	0.4	200	1.8×10^{4}	4.9×10^{-7}	370	2×10^{-3}
^{135}Xe	1/wk	16	0.4	200	2.3×10^{3}	6.2×10^{-8}	370	2×10^{-2}
Water Surveillance Network (LTHMP)[b]			Liters	Minutes	Bq/L	$\mu Ci/mL$	Bq/L	
^{3}H	1/mo	all	1	300	740	2×10^{-5}	12	1.6
$^{3}H^{+}$ (enriched tritium)	1/mo	all	0.25	300	740	2×10^{-5}	0.37	5×10^{-2}
^{89}Sr	1st time	all	1	50	16	4.4×10^{-7}	0.18	1.1
^{90}Sr	1st time	all	1	50	0.8	2.2×10^{-8}	0.074	9.2
^{137}Cs	1/mo	all	1	100	3.3	8.8×10^{-8}	0.33	10
^{226}Ra	1st time	all	1	1000	1.4	3.9×10^{-8}	0.037	2.6
^{234}U	1st time	all	1	1000	8.2	2.2×10^{-7}	0.0035	0.04
^{235}U	1st time	all	1	1000	10	2.8×10^{-8}	0.0035	0.035
^{238}U	1st time	all	1	1000	10	2.8×10^{-8}	0.0035	0.035
^{238}Pu	1st time	all	1	1000	6.2	1.7×10^{-8}	0.003	0.05
$^{239+240}Pu$	1st time	all	1	1000	4.1	1.1×10^{-8}	0.002	0.05
Gamma	1/mo	all	3.5	30	-	-	0.18	<0.2
Milk Surveillance Network			Liters	Minutes	Bq/L	$\mu Ci/mL$	Bq/L	
^{3}H	1/mo	all	3.5	300	12×10^{4}	3×10^{-3}	12	0.01
^{131}I	1/mo	all	3.5	100	41	1×10^{-6}	0.18	0.44
^{137}Cs	1/mo	all	3.5	100	160	4×10^{-6}	0.33	0.2
^{89}Sr	1/mo	all	3.5	50	820	2×10^{-5}	0.18	0.02

(continued)

TABLE 23. (Continued)

NUCLIDE	SAMPLING FREQUENCY	LOCATIONS	SAMPLE SIZE	COUNT TIME	CONCENTRATIONS GUIDE[a]		MDC	MDC (%CG)
Milk Surveillance Network			Liters	Minutes	Bq/L	µCi/mL	Bq/L	
^{90}Sr	1/mo	all	3.5	50	40	1×10^{-6}	0.074	0.18

Dosimetry Networks		Locations	Number	Exposure Guide	MDC	MDC (%CG)
TLD (Personnel)	1/mo	71	1	100mR	3.01 mrem	2
TLD (Station)	1/qtr	134	3 to 6	-	5.10 mrem	-
PIC	weekly	28	2016	-	2 µR/hr	-

[a]ALI and DAC values from ICRP-30 modified to 1 mSv annual effective dose equivalent for continuous exposure. Te and I data corrected to 2 g thyroid, greater milk intake, and smaller volume of air breathed annually (1 year-old infant).
[b]For tritium, Sr, and Cs the concentration guide is based on Drinking Water Regs. (4 mrem/yr) (CFR88).

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Glossary of Terms

Definitions of terms given here are modified from the U.S. Nuclear Regulatory Commission Glossary of terms (NRC81).

background radiation — The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of humans and animals. It is also called natural radiation. The usually quoted average individual exposure from background radiation is 125 millirem per year in midlatitudes at sea level.

beta particle (ß) — A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A positively charged beta particle is called a positron. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

becquerel (Bq) — A unit, in the International System of Units, of measurement of radioactivity equal to one nuclear transformation per second.

blind samples — A spiked sample unknown to the technician which has been introduced into the laboratory as a separate sample. These samples are used for the verification of analytical accuracy. Approximately one percent of the sample load shall be blind samples.

cosmic radiation — Penetrating ionizing radiation, both particulate and electromagnetic, originating in space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 125 millirem background radiation that an average individual receives in a year.

coulomb (C) — Unit of electrical charge in the MKSA system of units. A coulomb is a quantity of a charge equal to one ampere-second.

curie (Ci) — The basic unit used to describe the rate of radioactive disintegration. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium; named for Marie and Pierre Curie, who discovered radium in 1898.

dosimeter — A portable instrument for measuring and registering the total accumulated dose to ionizing radiation.

duplicate — A second aliquot of a sample which is approximately equal in mass or volume to the first aliquot and is analyzed for the sample parameters. The laboratory performs duplicate analyses to evaluate the precision of an analysis.

half-life — The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical halflife.

ionization — The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, nuclear radiation, and x-rays can cause ionization.

ionization chamber — An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber.

isotope — One of two or more atoms with the same number of protons, but different numbers of neutrons in their

	nuclei. Thus, ^{12}C, ^{13}C and ^{14}C are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, ^{12}C and ^{13}C are stable, ^{14}C is radioactive).
matrix spike	An aliquot of a sample which is spiked with a known concentration of the analyte of interest. The purpose of analyzing this type of sample is to evaluate to the effect of the sample matrix upon the analytical methodology.
method blank	A method blank is a volume of demineralized water for liquid samples, or an appropriate solid matrix for soil/sediment samples, carried through the entire analytical procedure. The volume or weight of the blank must be approximately equal to the volume or weight of the sample processed. Analysis of the blank verifies that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized.
minimum detectable concentration (MDC)	The smallest amount of radioactivity that can be reliably detected with a probability of Type I and Type II error at five percent each (DOE81).
millirem (mrem)	A one-thousandth part of a rem. (See rem.)
milliroentgen (mR)	A one-thousandth part of a roentgen. (See roentgen.)
noble gas	A gaseous element that does not readily enter into chemical combination with other elements. An inert gas.
personnel monitoring	The determination of the degree of radioactive contamination on individuals using survey meters, or the determination of radiation dosage received by means of dosimetry methods.
picocurie (pCi)	One trillionth part of a curie.
quality factor	The factor by which the absorbed dose is to be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiations, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than other types.
rad	Acronym for radiation absorbed dose. The basic unit of absorbed dose of radiation. A dose of one rad means the absorption of 100 ergs (a small but measurable amount of energy) per gram of absorbing material.
radioisotope	An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.
radionuclide	A radioisotope.
rem	Acronym of roentgen equivalent man. The unit of dose of any ionizing radiation that produces the same biological effect as a unit of absorbed dose of ordinary X-rays. (See quality factor.)
roentgen (R)	A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered X-rays in 1895.
scintillation (detector or counter)	The combination of phosphor, photomultiplier tube, and associated counter electronic circuits for counting light emissions produced in the phosphor by ionizing radiation.
sievert (Sv)	A unit, in the International System of Units (SI), of dose equivalent which is equal to one joule per kilogram (1 Sv equals 100 rem).

terrestrial radiation	The portion of natural radiation (background) that is emitted by naturally occurring radioactive materials in the earth.
tritium	A radioactive isotope of hydrogen that decays by beta emission. It's half-life is about 12.5 years.
verification/ reference standard	A prepared sample of known concentration of a purchased standard reference material. These samples are analyzed in triplicate and the results are used to verify accuracy and precision of the procedure.
X-rays	Penetrating electromagnetic radiation (photon) having a wavelength that is much shorter than that of visible light. These rays are usually produced by excitation of the electron field around certain nuclei. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and to those originating in the electron field of the atom as X-rays. These rays are sometimes called roentgen rays after their discoverer, Wilhelm K. Roentgen.

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Appendix
Supplementary Figures and Tables

Included here are additional figures and tables, presented in the order in which they are referenced in the text. The figures include the box-and-whisker plots of 1990 and historical data. A description of the box-and-whisker plots is presented in Section 6.4.1. A listing of the contents of this Appendix follows:

Figures

Tables

TABLE A1. CONCENTRATIONS OF ^{238}Pu AND $^{239+240}Pu$ (Composited Air Samples — 1989 and 1990)

COMPOSITE SAMPLING LOCATION	COLLECTION DATE	CONCENTRATION ± 1 S. D. (MDC) ^{238}PU (10^{-18} µCi/mL)	$^{239+240}PU$ (10^{-18} µCi/mL)
WINSLOW & TUCSON AZ	08/02/89	7.6 ± 17 (50)	-7.6 ± 7.7 (36)
	11/01/89	46 ± 40 (110)	-11 ± 11 (53)
	01/26/90	8.9 ± 5.9 (15)	3 ± -3 (6.9)
	05/02/90	80 ± 81 (190)	40 ± -70 (190)
	09/17/90	4 ± 7.7 (21)	4 ± 9.8 (29)
	12/19/90	6 ± 11 (29)	0 ± 8.8 (29)
BISHOP & RIDGECREST CA	08/23/89	21 ± 26 (74)	0 ± 10 (33)
	11/01/89	-0.03 ± 200 (670)	0 ± 100 (330)
	01/11/90	6.2 ± 5.8 (16)	-1.5 ± 1.5 (7.2)
	05/02/90	-43 ± 38 (150)	14 ± 25 (66)
	08/09/90	-9 ± 21 (76)	-9 ± 9.5 (44)
	11/09/90	10 ± 18 (49)	10 ± 18 (49)
DENVER & CORTEZ CO	08/21/89	28 ± 25 (66)	-7.1 ± 12 (47)
	11/01/89	25 ± 36 (100)	0 ± 18 (59)
	03/01/90	8.9 ± 6.4 (17)	0 ± 2.5 (8.3)
	06/27/90	29 ± 29 (67)	-14 ± 14 (67)
	08/20/90	33 ± 33 (77)	0 ± 23 (77)
	11/28/90	0 ± 19 (63)	-14 ± 14 (63)
NAMPA & MOUNTAIN HOME ID	09/18/89	14 ± 26 (80)	0 ± 9.9 (33)
	11/12/89	11 ± 22 (67)	0 ± 11 (36)
	01/29/90	14 ± 7.5 (18)	0 ± 2.7 (9)
	05/02/90	-6.5 ± 20 (68)	0 ± 9.2 (30)
	07/23/90	14 ± 14 (33)	-7 ± 7.2 (33)
	10/22/90	-19 ± 19 (88)	0 ± 27 (88)
CLAYTON & JOPLIN MO	08/28/89	0 ± 8.2 (27)	-4.1 ± 4.1 (19)
	11/03/89	-58 ± 150 (540)	58 ± 100 (270)
	03/01/90	-7.9 ± 21 (73)	0 ± 11 (37)
	06/25/90	SAMPLE LOST	SAMPLE LOST
	09/17/90	10 ± 17 (46)	10 ± 17 (46)
	11/26/90	-5 ± 9 (35)	5 ± 9 (24)
GREAT FALLS & MILES CITY MT	08/21/89	-5.2 ± 7.4 (27)	0 ± 3.7 (12)
	11/01/90	-33 ± 87 (300)	0 ± 46 (150)
	01/25/90	6.8 ± 23 (71)	6.8 ± 12 (32)
	05/02/89	18 ± 32 (96)	-9.2 ± 9.3 (43)
	09/17/90	0 ± 10 (33)	7 ± 12 (33)
	12/28/90	0 ± 9.9 (33)	5 ± 8.6 (23)
LAS VEGAS NV	07/30/89	-28 ± 15 (64)	0 ± 7.9 (26)
	08/28/89	0 ± 2.5 (8.3)	2 ± 1.8 (4.4)
	09/25/89	0 ± 14 (45)	-4.8 ± 4.8 (22)
	10/30/89	2.6 ± 7.8 (24)	0 ± 3.7 (12)
	11/27/89	17 ± 8.6 (20)	0 ± 3.1 (10)
	12/25/89	-51 ± 31 (130)	0 ± 20 (67)
	01/29/90	4.9 ± 2.7 (6.6)	2.1 ± 1.6 (3.3)
	02/26/90	2.4 ± 4.2 (13)	2.4 ± 2.4 (5.6)
	03/26/90	7.5 ± 3.8 (8.7)	0.9 ± 1.6 (4.4)
	04/30/90	2.1 ± 3.7 (9.9)	2.1 ± 3.7 (9.9)
	05/29/90	-27 ± 24 (93)	27 ± 20 (42)
	06/25/90	4.8 ± 8.4 (23)	0 ± 6.8 (23)
	07/29/90	-8.8 ± 8.8 (36)	4.4 ± 7.7 (21)
	08/27/90	-5.5 ± 5.5 (26)	-5.5 ± 9.5 (36)

(continued)

TABLE A1. Continued

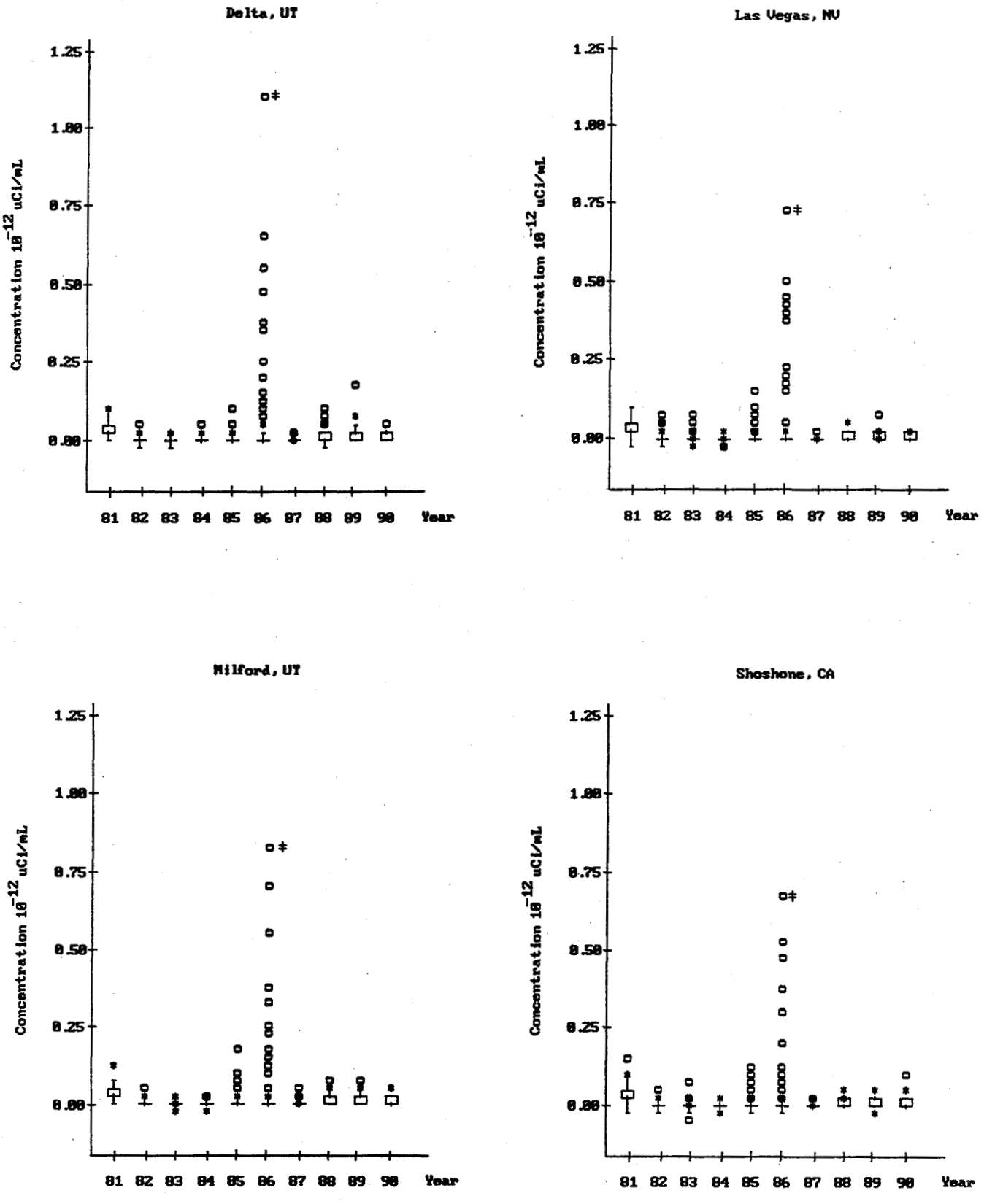
COMPOSITE SAMPLING LOCATION	COLLECTION DATE	CONCENTRATION ± 1 S. D. (MDC) ^{238}PU (10^{-18} µCi/mL)	CONCENTRATION ± 1 S. D. (MDC) $^{239+240}PU$ (10^{-18} µCi/mL)
	09/24/90	-2.8 ± 2.8 (13)	2.8 ± 4.8 (13)
	10/08/90	1 ± 2.3 (6.9)	3.1 ± 2.4 (4.9)
	11/26/90	3.7 ± 4.4 (12)	5.5 ± 4.1 (8.5)
	12/31/90	*11 ± 5.8 (10)	0 ± 3.1 (10)
LATHROP WELLS NV	07/30/89	12 ± 6.6 (14)	-4.1 ± 2.9 (14)
	08/28/89	-2.9 ± 9.6 (33)	0 ± 4.1 (13)
	09/24/89	-3.9 ± 4.3 (16)	1.3 ± 2.9 (8.5)
	10/29/89	-22 ± 24 (91)	7.4 ± 16 (49)
	11/27/89	24 ± 21 (56)	-6 ± 5.9 (28)
	12/26/89	-13 ± 9.6 (40)	0 ± 6 (20)
	01/28/90	3.7 ± 2.6 (6.8)	-0.7 ± 1.6 (5.9)
	02/26/90	6.2 ± 3.1 (7.3)	2.3 ± 1.7 (3.6)
	03/26/90	3 ± 3.6 (11)	2 ± 2 (4.7)
	04/29/90	-21 ± 13 (53)	5.1 ± 8.9 (24)
	05/27/90	5.3 ± 9.2 (25)	16 ± 12 (25)
	06/24/90	-2.9 ± 8.8 (13)	2.9 ± 5.1 (14)
	07/30/90	6.7 ± 12 (31)	-6.7 ± 6.8 (31)
	08/26/90	0 ± 12 (41)	8.8 ± 2.0 (58)
	09/30/90	0 ± 14 (47)	-5.8 ± 5.8 (27)
	10/28/90	SAMPLE LOST	SAMPLE LOST
	11/25/90	-9.6 ± 17 (63)	9.6 ± 17 (45)
	12/30/90	12 ± 8.6 (20)	0 ± 4.2 (14)
RACHEL NV	07/31/89	2.7 ± 8.3 (26)	0 ± 3.9 (13)
	08/28/89	9.6 ± 5.1 (11)	1.6 ± 3.6 (11)
	09/25/89	0 ± 2.9 (9.6)	3.4 ± 2.1 (3.9)
	10/30/89	24 ± 19 (48)	-5.9 ± 5.9 (28)
	11/27/89	-43 ± 34 (130)	11 ± 24 (71)
	12/26/89	-4.5 ± 12 (42)	4.5 ± 7.8 (21)
	01/28/90	6.1 ± 3.1 (7)	1.7 ± 1.7 (4)
	02/26/90	8.2 ± 3.8 (8.5)	-0.9 ± 2 (7.4)
	03/26/90	*6.2 ± 2.6 (5.9)	1.1 ± 1.1 (2.6)
	04/30/90	4.3 ± 7.5 (20)	8.6 ± 8.6 (20)
	05/28/90	-29 ± 18 (20)	0 ± 10 (34)
	06/25/90	34 ± 26 (54)	23 ± 23 (54)
	07/29/90	-8 ± 18 (64)	-8 ± 8 (37)
	08/26/90	-5.9 ± 5.9 (28)	0 ± 8.4 (28)
	09/23/90	6.7 ± 6.7 (16)	0 ± 4.7 (16)
	10/28/90	-3.5 ± 3.5 (16)	0 ± 5 (16)
	11/25/90	1.9 ± 3.3 (8.8)	3.8 ± 3.8 (8.8)
	12/25/90	1.7 ± 2.9 (7.8)	0 ± 2.4 (7.8)
ALBUQUERQUE & CARLSBAD NM	08/21/89	0 ± 14 (47)	-5.1 ± 8.8 (34)
	11/01/89	32 ± 32 (86)	-11 ± 11 (50)
	01/29/90	13 ± 11 (27)	-3.4 ± 3.4 (16)
	05/02/90	35 ± 61 (160)	-35 ± 35 (160)
	09/17/90	12 ± 21 (56)	-12 ± 12 (56)
	11/26/90	-6.8 ± 6.8 (32)	6.8 ± 12 (32)
BISMARCK & FARGO ND	08/21/89	-28 ± 28 (110)	-9.4 ± 9.4 (44)
	10/31/89	-110 ± 87 (300)	-27 ± 47 (180)
	02/05/90	19 ± 9.6 (22)	-2.4 ± 5.4 (19)
	09/24/90	0 ± 20 (65)	0 ± 20 (65)
	11/26/90	-3.8 ± 3.8 (18)	-3.8 ± 3.8 (18)

(continued)

TABLE A1. Continued

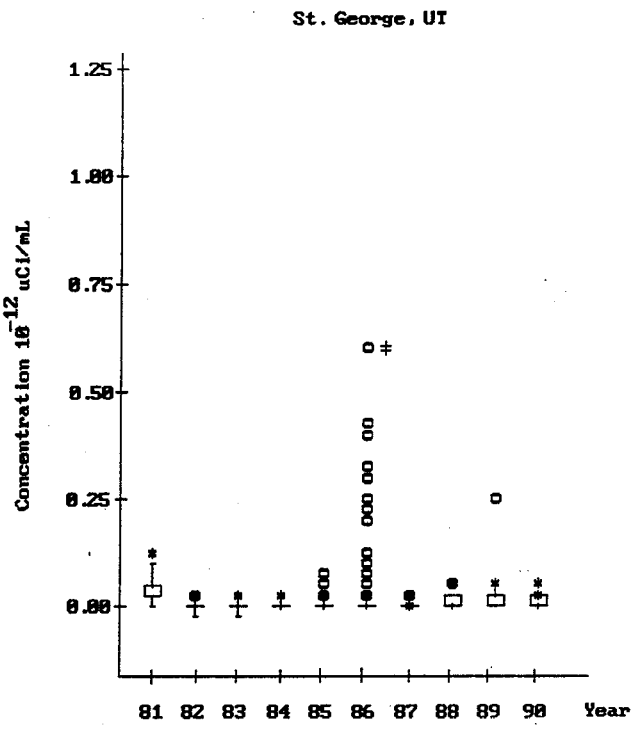
COMPOSITE SAMPLING LOCATION	COLLECTION DATE	CONCENTRATION ± 1 S. D. (MDC) ^{238}PU (10^{-18} μCi/mL)	$^{239+240}PU$ (10^{-18} μCi/mL)
BURNS & MEDFORD OR	08/04/89	13 ± 17 (44)	0 ± 9.5 (31)
	10/31/89	-40 ± 110 (380)	0 ± 57 (190)
	01/26/90	0 ± 25 (83)	8.9 ± 15 (42)
	05/10/90	0 ± 15 (48)	10 ± 18 (48)
	09/21/90	41 ± 25 (48)	10 ± 24 (67)
	12/03/90	0 ± 12 (40)	24 ± 15 (28)
AUSTIN & AMARILLO TX	08/23/89	-23 ± 33 (120)	0 ± 16 (54)
	12/11/89	23 ± 62 (190)	0 ± 33 (110)
	03/30/90	3.2 ± 11 (33)	-3.2 ± 3.2 (15)
	06/28/90	-43 ± 62 (230)	22 ± 38 (100)
	11/28/90	0 ± 13 (44)	*33 ± 18 (31)
LOGAN & VERNAL UT	08/21/89	SAMPLE LOST	SAMPLE LOST
	11/01/89	55 ± 79 (220)	28 ± 48 (130)
	01/29/90	14 ± 11 (27)	0 ± 4.8 (16)
	06/28/90	13 ± 23 (61)	0 ± 18 (61)
	09/18/90	21 ± 21 (49)	0 ± 21 (69)
	12/31/90	6.8 ± 12 (32)	0 ± 9.6 (32)
SALT LAKE CITY UT	07/31/89	3.5 ± 7.1 (22)	1.8 ± 3.9 (12)
	08/28/89	9.6 ± 6.9 (18)	-1.9 ± 1.9 (9)
	09/25/89	5.7 ± 5.1 (13)	-1.9 ± 3.3 (13)
	10/30/89	10 ± 11 (32)	-3.4 ± 3.4 (16)
	11/27/89	6.8 ± 18 (55)	-6.8 ± 6.8 (32)
	12/26/89	5.8 ± 23 (72)	0 ± 12 (38)
	01/29/90	10 ± 4.9 (12)	-1.1 ± 1.1 (5.2)
	02/26/90	7.6 ± 3.5 (7.6)	1.9 ± 1.9 (4.4)
	03/26/90	4.2 ± 3 (7.7)	-0.8 ± 0.8 (3.9)
	04/30/90	-1.9 ± 5.7 (20)	3.8 ± 3.8 (8.8)
	05/28/90	11 ± 11 (25)	-5.3 ± 5.3 (25)
	06/25/90	-27 ± 17 (71)	0 ± 9.7 (32)
	07/30/90	-12 ± 12 (55)	12 ± 20 (55)
	08/27/90	13 ± 13 (31)	6.5 ± 11 (31)
	09/24/90	5.9 ± 5.9 (14)	-5.9 ± 4.2 (20)
	10/29/90	-1.8 ± 3 (12)	5.2 ± 3.9 (8.1)
	11/26/90	-2.9 ± 5.1 (19)	8.8 ± 6.6 (14)
	12/31/90	0 ± 2.3 (7.6)	0 ± 2.3 (7.6)
SEATTLE & SPOKANE WA	08/18/89	0 ± 10 (33)	5.8 ± 5.8 (14)
	10/31/89	-54 ± 43 (170)	0 ± 27 (89)
	01/25/90	-8.5 ± 25 (88)	8.5 ± 15 (40)
	05/02/90	SAMPLE LOST	SAMPLE LOST
	09/24/90	15 ± 26 (70)	15 ± 26 (70)
	11/28/90	7.2 ± 7.2 (17)	3.6 ± 6.3 (17)
WORLAND & ROCK SPRINGS WY	09/04/89	-9.4 ± 16 (62)	9.4 ± 16 (44)
	11/01/89	60 ± 67 (190)	0 ± 28 (93)
	02/05/90	7.6 ± 8.4 (24)	5.1 ± 5.1 (12)
	05/28/90	SAMPLE LOST	SAMPLE LOST
	09/27/90	-4.8 ± 11 (39)	4.8 ± 8.4 (23)
	11/27/90	17 ± 30 (114)	0 ± 24 (81)

All concentrations above the minimum detectable concentration (MDC) are denoted by an asterisk (*).



‡ Elevated concentrations attributed to April 1986 Accident at Chernobyl, U.S.S.R.

Figure A1. Historical gross beta trends in air samples - monthly averages.



A1. Continued

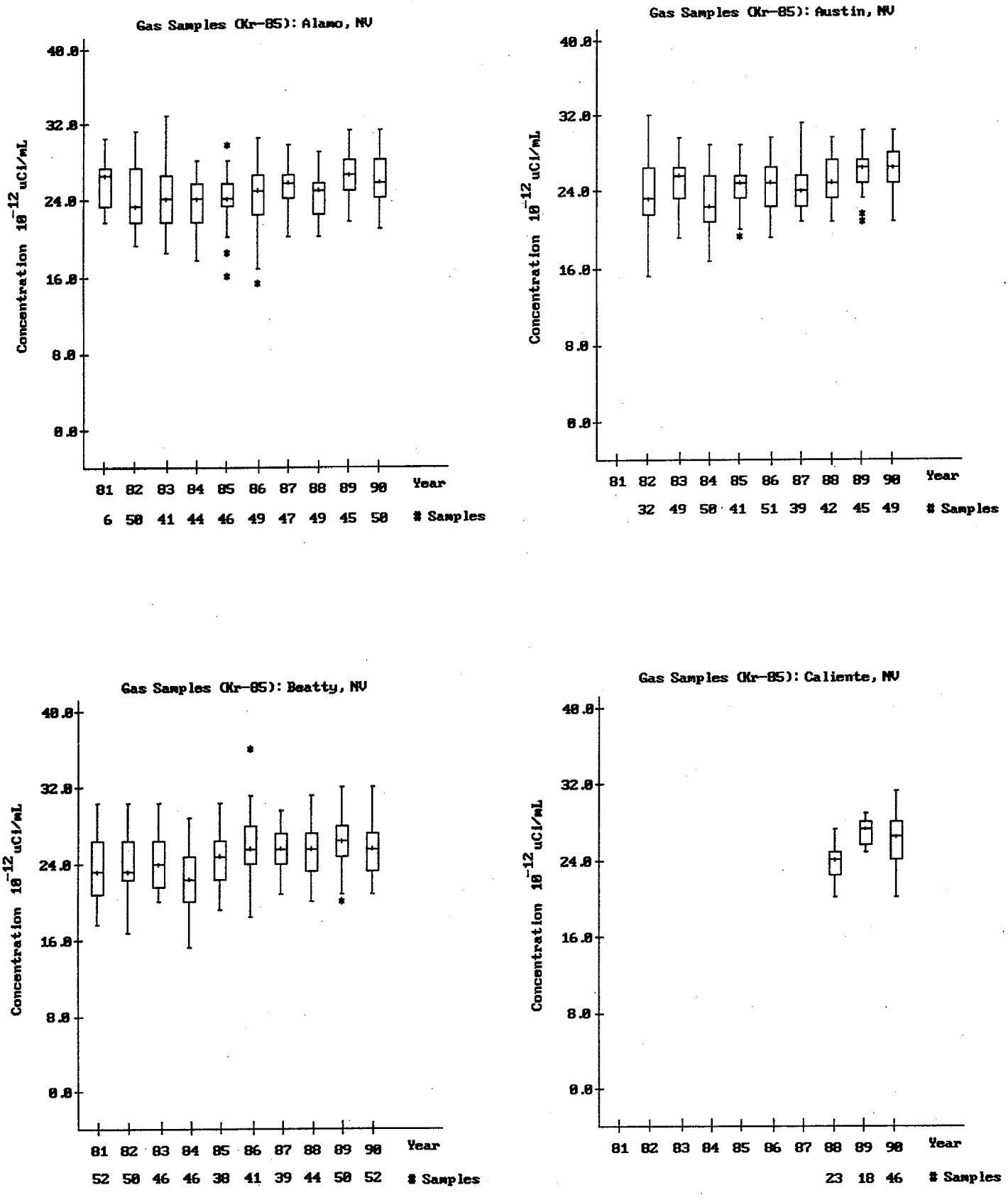
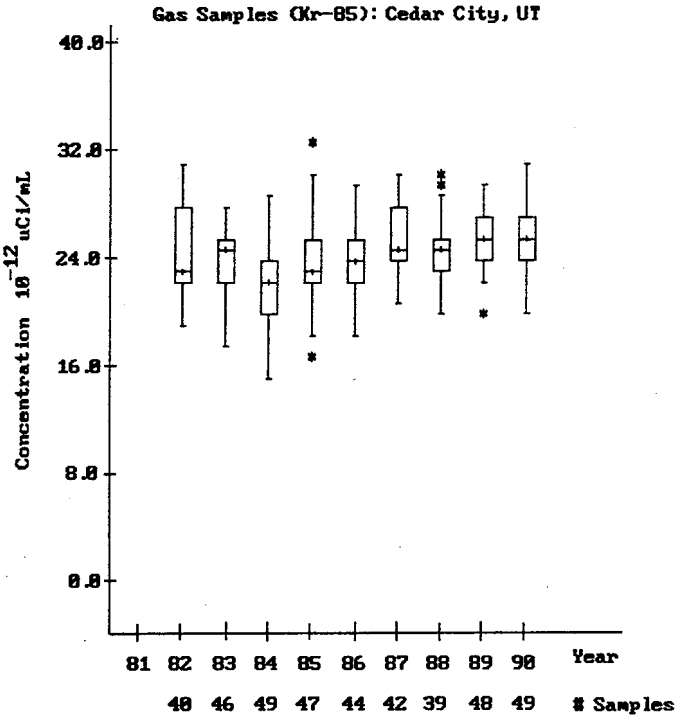
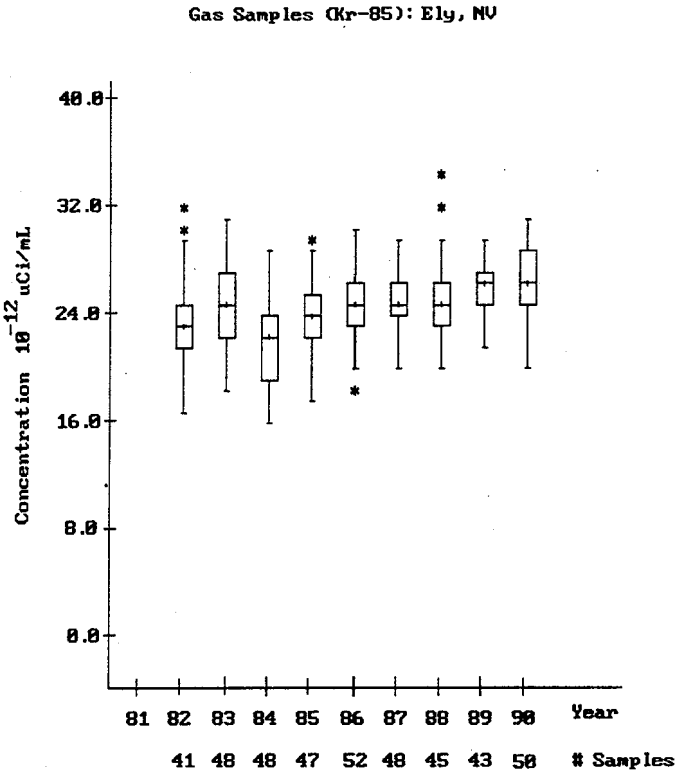
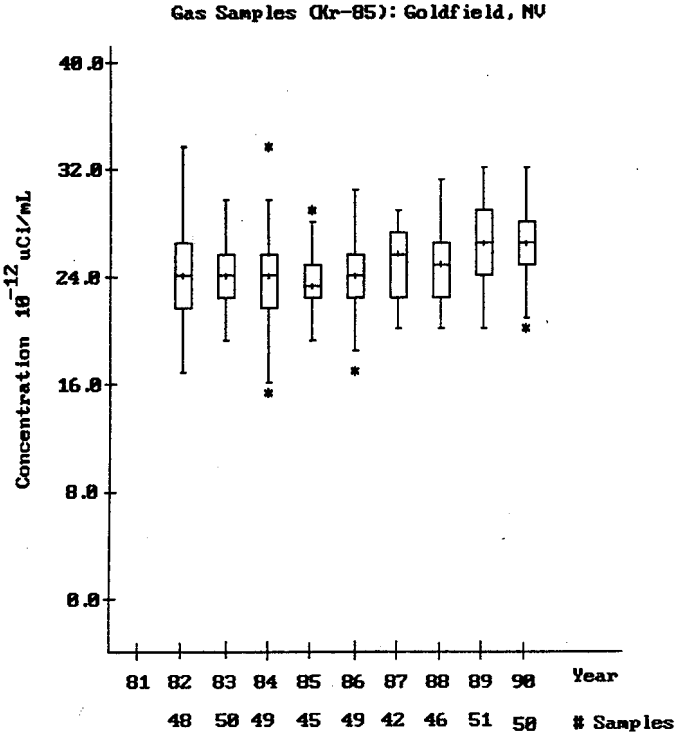


Figure A2. Historical ^{85}Kr trends in air samples - monthly averages.







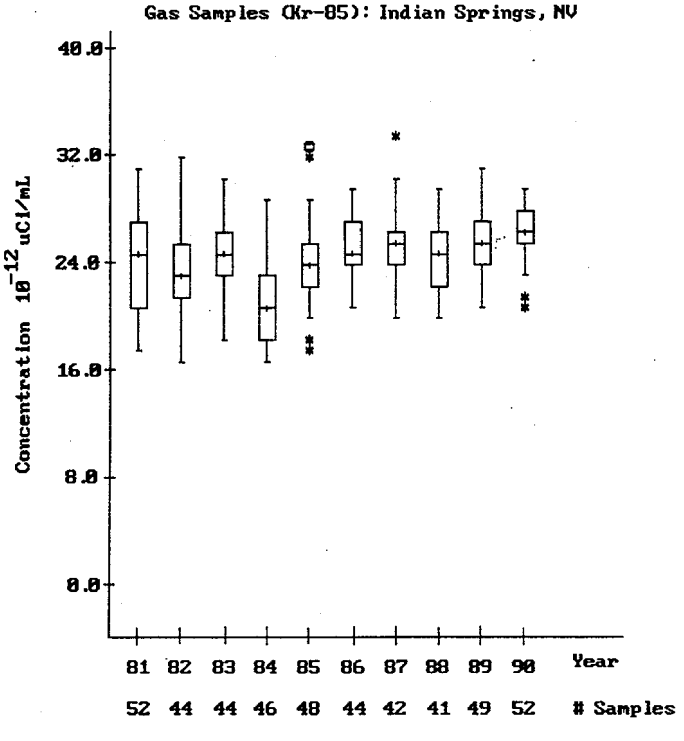


Figure A2. Continued.

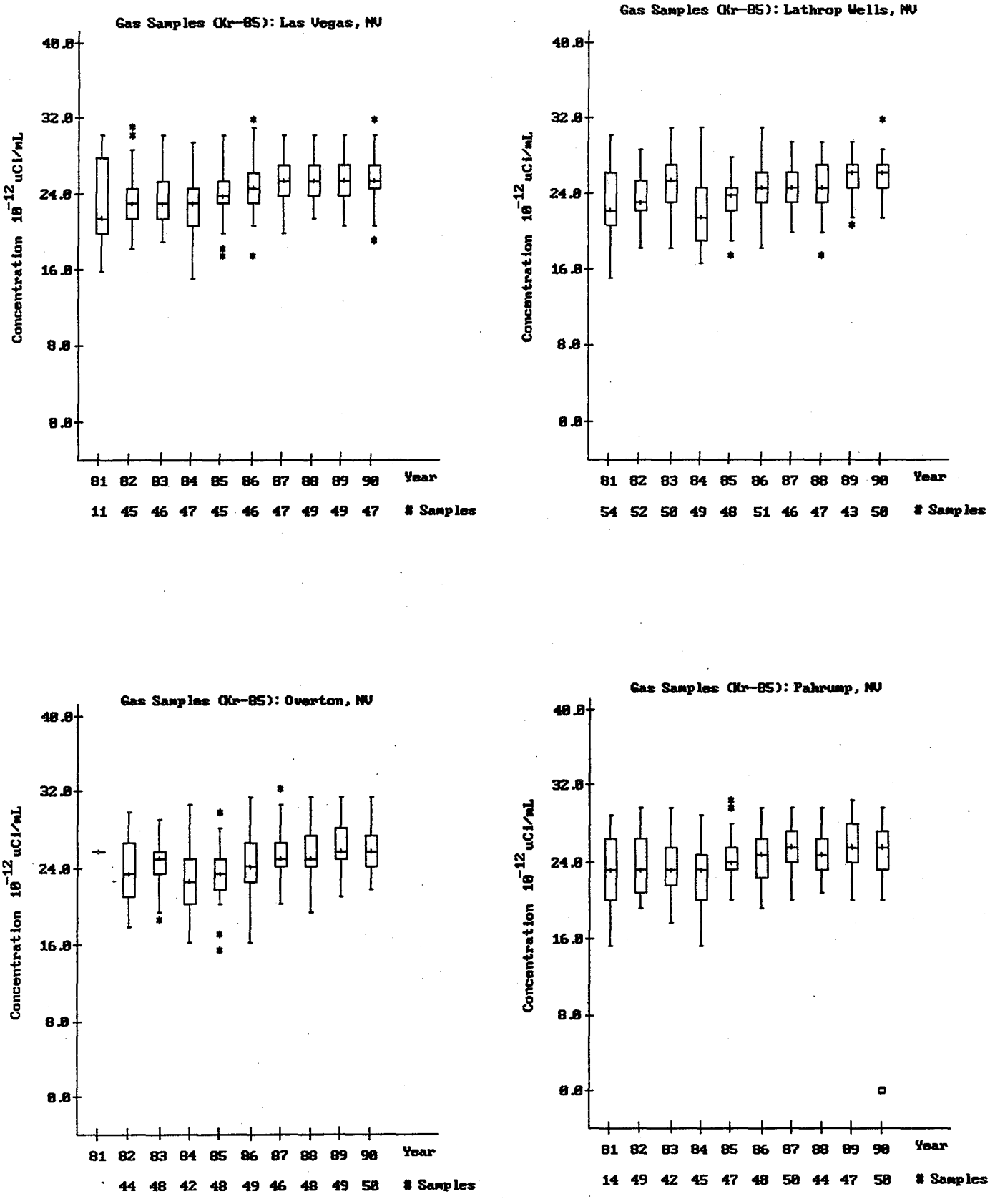
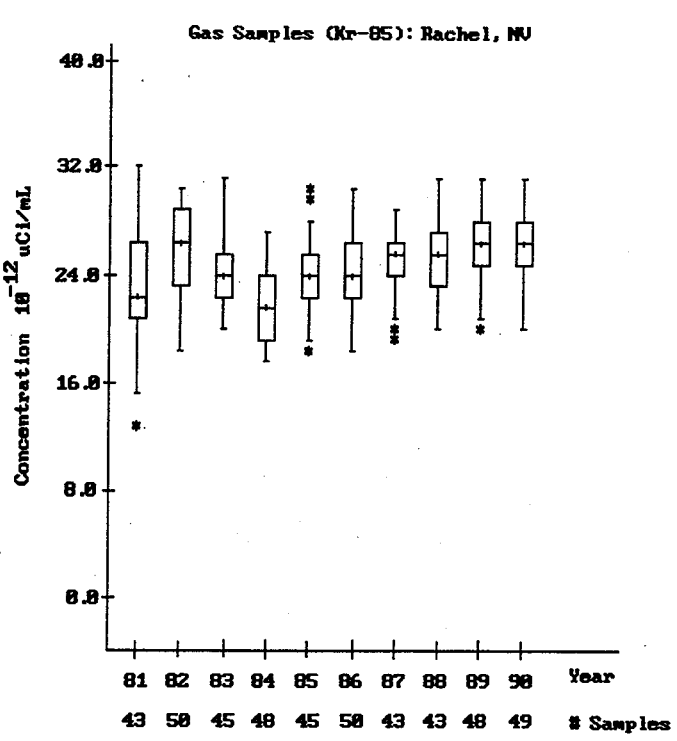
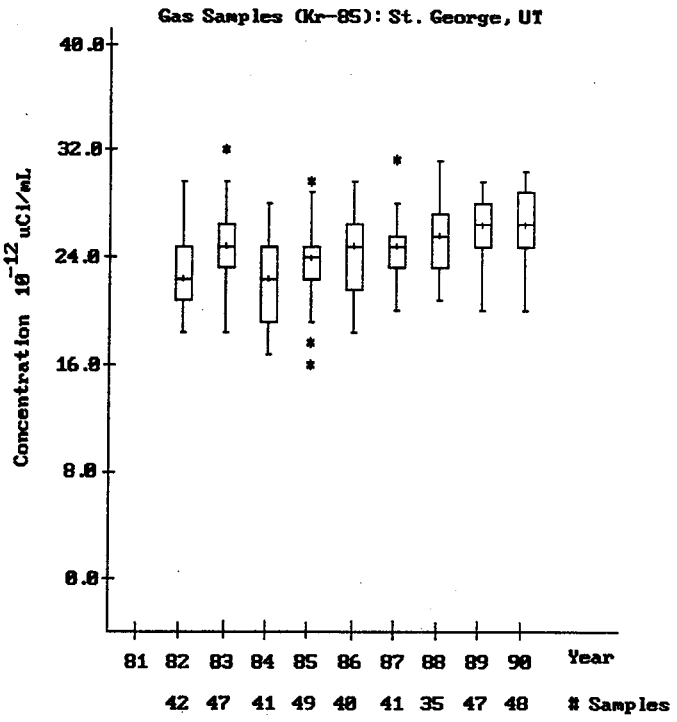
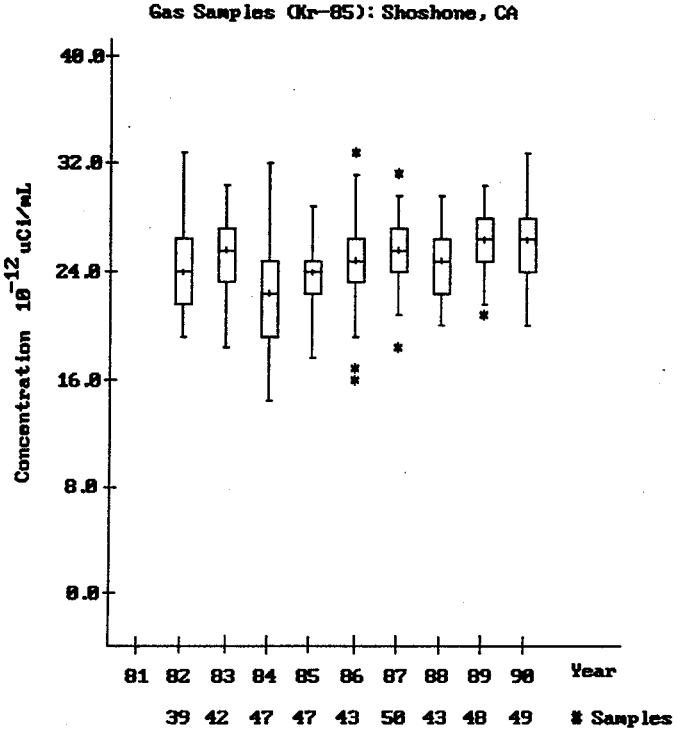


Figure A2. Continued.







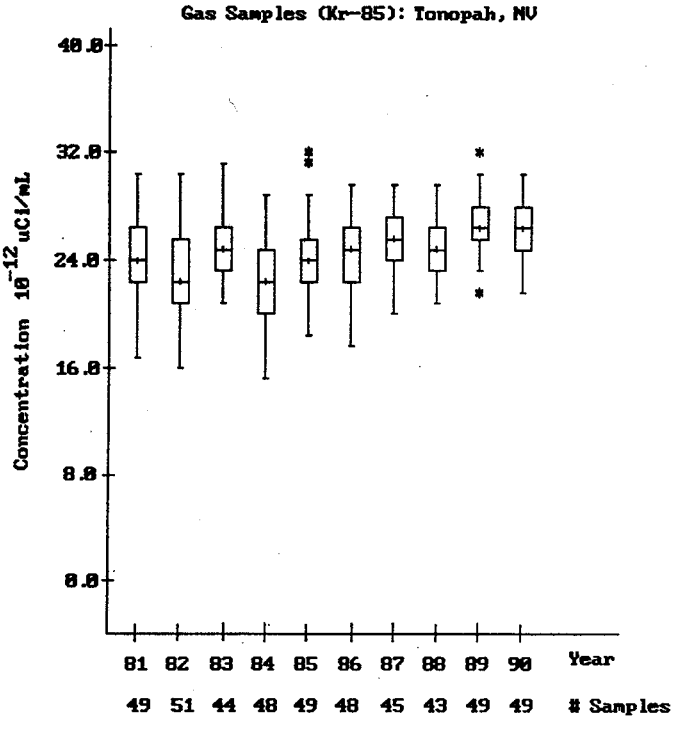


Figure A2. Continued.

TABLE A2. SUMMARY OF ANALYTICAL RESULTS FOR THE MILK SURVEILLANCE NETWORK — 1990

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-9} µCi/mL)[a]	^{90}Sr (10^{-9} µCi/mL)[a]	^{90}Sr (10^{-9} µCi/mL)[a]
BENTON CA				
I. BROWN RANCH	01/05	110 ± 120 (400)		0.23 ± 0.59 (2.2)
	02/08		[b]	-0.10 ± 0.39 (1.6)
	03/09		[b]	
	04/02	45 ± 140 (460)		-0.10 ± 0.39 (1.6)
	05/03		[b]	
	06/05		[b]	
	07/19	-40 ± 120 (420)		0.19 ± 0.41 (1.6)
	08/09			
	09/06			
	10/04	260 ± 140 (450)	-0.14 ± 2 (2.7)	0.63 ± 0.41 (1.5)
	11/01			
	12/05			
HINKLEY CA				
DESERT VIEW DAIRY	01/03	-45 ± 120 (400)	[b]	0.061 ± 0.51 (1.9)
	02/07			
	03/15			
	04/02	-140 ± 130 (430)	[b]	0.052 ± 0.34 (1.4)
	05/02			
	06/05			
	07/18	-13 ± 120 (400)	1.0 ± 1.1 (1.5)	0.54 ± 0.35 (1.3)
	09/05			
	10/02	260 ± 170 (550)	0.37 ± 1.9 (2.5)	0.48 ± 0.39 (1.5)
HINKLEY CA				
BILL NELSON DAIRY	08/07			
	11/01			
	12/05			
RIDGECREST CA				
CEDARSAGE FARM	01/03	-85 ± 120 (400)	[b]	-0.36 ± 0.51 (2.0)
	02/07			
	03/15			
	04/02	-16 ± 120 (420)	[b]	-0.32 ± 0.37 (1.5)
	05/02			
	06/05			
	07/18	-55 ± 120 (420)	-1.1 ± 1 (1.6)	0.50 ± 0.32 (1.4)
	08/08			
	09/05			
	10/03	210 ± 150 (500)	[b]	0.23 ± 0.38 (1.6)
	11/01			
	12/05			
ALAMO NV				
COURTNEY DAHL RANCH	02/06		NO SAMPLE - NO MILK	
	03/07	220 ± 130 (410)	[b]	0.69 ± 0.52 (1.8)
	03/28		NO SAMPLE - COW SICK	
	05/02	290 ± 140 (450)	0.32 ± 1.3 (2.1)	0.26 ± 0.31 (1.3)
	06/01			
	07/11			
	08/15	180 ± 120 (370)	0.85 ± 1.9 (3)	0.46 ± 0.38 (1.5)
	09/11			
	10/01			
	11/01	-24 ± 140 (480)	[b]	-0.19 ± 0.39 (1.6)
	12/05			

(continued)

TABLE A2. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-9} µCi/mL)[a]	^{89}SR (10^{-9} µCi/mL)[a]	^{90}SR (10^{-9} µCi/mL)[a]
AUSTIN NV				
YOUNG'S RANCH	01/19		NO SAMPLE - COW DRY	
	02/15		NO SAMPLE - COW DRY	
	03/15	250 ± 120 (390)	[b]	1.1 ± 0.35 (1.4)
	04/11			
	05/08			
	06/06	180 ± 120 (420)	0.54 ± 1.5 (2.0)	0.87 ± 0.39 (1.4)
	07/18			
	08/16			
	09/13	220 ± 120 (370)	[b]	0.092 ± 0.37 (1.5)
	10/04			
	11/07			
	12/12	160 ± 140 (480)	[b]	0.77 ± 0.38 (1.4)
BLUE JAY NV				
BLUE JAY SPRGS-JIM BIAS R	01/10			
	02/12			
	03/08	330 ± 120 (400)	[b]	1 ± 0.39 (1.4)
	04/11			
	05/02			
	06/11		NO SAMPLE - GOAT DRY	
	07/18			
	08/09			
	09/06	5.1 ± 110 (380)	[b]	0.57 ± 0.41 (1.5)
	10/11			
	11/13			
CALIENTE NV				
JUNE COX RANCH	01/08			
	02/05	130 ± 120 (390)	[b]	0.15 ± 0.43 (1.6)
	03/01			
	03/27			
	05/07	150 ± 130 (440)	0.63 ± 1.5 (2.1)	0.99 ± 0.36 (1.3)
	06/01			
	07/10			
	08/06	110 ± 120 (380)	-0.74 ± 2.2 (3.1)	0.74 ± 0.39 (1.5)
	09/05			
	10/01			
	11/01	110 ± 140 (480)	0.18 ± 1.7 (2.7)	-0.13 ± 0.39 (1.7)
	12/04			
CURRANT NV				
BLUE EAGLE RANCH	01/03			
	02/13			
	03/07	92 ± 120 (400)	[b]	0.63 ± 0.35 (1.4)
	04/09			
	05/01		NO SAMPLE - NO ONE HOME	
	06/11	160 ± 130 (430)	-0.32 ± 1.2 (1.8)	0.55 ± 0.34 (1.4)
	08/13		NO MILK AVAILABLE	
	09/06		NO SAMPLE - COW DRY	
CURRANT NV				
MANZONIE RANCH	01/03			
	03/07	310 ± 130 (420)	[b]	0.90 ± 0.35 (1.4)
	04/11		NO SAMPLE - COW DRY	

(continued)

TABLE A2. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-6} µCi/mL)[a]	^{89}SR (10^{-6} µCi/mL)[a]	^{90}SR (10^{-6} µCi/mL)[a]
DYER NV				
OZEL LEMON	01/24			
	02/14			
	03/09	110 ± 120 (400)	[b]	0.90 ± 0.40 (1.6)
	04/12			
	05/10			
	06/07	93 ± 120 (420)	0.73 ± 1.4 (1.9)	0.76 ± 0.38 (1.4)
	07/19			
	08/15			
	09/06	160 ± 110 (370)	[b]	0.019 ± 0.39 (1.5)
	10/02			
	11/13			
	12/06	200 ± 160 (510)	[b]	0.29 ± 0.55 (1.8)
ELY NV				
MCKAY, ROBERT AND CARLA	01/09		NO SAMPLE - COW DRY	
	02/05	220 ± 120 (400)	[b]	0.66 ± 0.74 (2.5)
	03/01			
	03/27			
	05/07	330 ± 150 (500)	-0.57 ± 1.4 (2.1)	0.76 ± 0.33 (1.4)
	06/01			
	07/11			
	08/06	140 ± 110 (370)	-2.6 ± 2.4 (3.5)	1.1 ± 0.43 (1.7)
	09/02		NO SAMPLE - COW DRY	
	09/05			
	11/01		NO SAMPLE - COW DRY	
	12/05	320 ± 170 (550)	[b]	0.22 ± 0.50 (1.8)
GOLDFIELD NV				
FRAYNE RANCH	01/19		NO SAMPLE - GOAT DRY	
	06/07		NO SAMPLE - GOAT DRY	
	07/24		NO SAMPLE - GOAT DRY	
	08/17		NO SAMPLE - GOAT DRY	
	09/14	180 ± 110 (360)	[b]	0.91 ± 0.42 (1.6)
	10/10			
	11/15		NO SAMPLE - GOAT DRY	
	12/12		NO SAMPLE - GOAT DRY	
GOLDFIELD NV				
SUSIE SCOTT RANCH	01/19		NO SAMPLE - GOAT DRY	
	04/12		NO SAMPLE - GOAT DRY	
	05/10			
	06/07	230 ± 120 (400)	1.8 ± 1.6 (2.0)	0.41 ± 0.40 (1.5)
	07/20			
	08/17		NO SAMPLE - GOAT DRY	
INDIAN SPRINGS NV				
SUSAN CARR RANCH	01/02			
	02/05	-29 ± 120 (400)	[b]	0.85 ± 0.38 (1.4)
	03/05		NO SAMPLE - GOAT DRY	
AMARGOSA VALLEY NV				
JOHN DEERE RANCH	01/05		NO SAMPLE - GOAT DRY	
	04/04			
	05/09			
	06/06	-34 ± 130 (440)	0.89 ± 1.4 (1.9)	0.33 ± 0.36 (1.4)
	07/10		NO SAMPLE - GOAT DRY	

(continued)

TABLE A2. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-9} µCi/mL)[a]	^{89}SR (10^{-9} µCi/mL)[a]	^{90}SR (10^{-9} µCi/mL)[a]
LOGANDALE NV				
LEONARD MARSHALL	01/04			
RANCH	02/08	220 ± 120 (390)	[b]	0.24 ± 0.37 (1.5)
	03/01			
	03/25			
	05/02	310 ± 130 (430)	-0.71 ± 1.4 (2.2)	0.38 ± 0.30 (1.3)
	06/04			
	07/02			
	08/06	170 ± 110 (360)	0.050 ± 2.6 (4.2)	0.34 ± 0.44 (1.8)
	09/05			
	10/04		NO SAMPLE - COW DRY	
	11/01	170 ± 180 (580)	0.73 ± 2.7 (4.1)	-0.11 ± 0.58 (2.2)
	12/04			
LUND NV				
RONALD J HORSLEY RANCH	01/09		NO SAMPLE - COW DRY	
	02/06	-28 ± 120 (400)	[b]	0.26 ± 0.40 (1.6)
	03/01			
	03/28			
	05/18	200 ± 130 (440)	-0.42 ± 1.1 (1.8)	0.97 ± 0.32 (1.3)
	06/04			
	07/11			
	08/07	56 ± 97 (320)	1.3 ± 2.7 (3.5)	0.48 ± 0.56 (1.9)
	09/05			
	10/02			
	11/01	220 ± 160 (540)	0.11 ± 1.7 (2.8)	-0.021 ± 0.40 (1.7)
	12/12			
MESQUITE NV				
HAFEN DAIRY	06/28	-5.6 ± 130 (430)	-0.043 ± 1.3 (2.0)	0.56 ± 0.33 (1.3)
	08/06			
	09/05			
	09/28	240 ± 150 (490)	[b]	0.30 ± 0.37 (1.5)
	11/01			
	12/04			
MESQUITE NV				
SPEDA BROTHERS DAIRY	01/04	9.9 ± 120 (410)	[b]	0.35 ± 0.37 (1.5)
	02/08			
	03/01			
	03/26	230 ± 130 (430)	[b]	0.32 ± 0.36 (1.5)
	05/02			
	06/01			
MOAPA NV				
ROCKVIEW DAIRIES, INC.	01/04	140 ± 120 (420)	[b]	1.1 ± 0.35 (1.4)
	02/08			
	03/01			
	03/26	120 ± 130 (440)	[b]	0.40 ± 0.34 (1.5)
	05/02			
	06/04			
	07/02	-180 ± 120 (420)	0.00065 ± 2 (2.7)	0.96 ± 0.49 (1.7)
	08/06			
	09/06			
	10/04	180 ± 150 (500)	2.2 ± 1.9 (2.7)	0.034 ± 0.40 (1.5)
	11/01			
	12/04			

(continued)

TABLE A2. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-9} µCi/mL)[a]	^{89}SR (10^{-9} µCi/mL)[a]	^{90}SR (10^{-9} µCi/mL)[a]
NYALA NV				
SHARP RANCH	01/09			
	02/06			
	03/07	130 ± 120 (400)	[b]	0.37 ± 0.39 (1.6)
	04/10			
	05/01			
	06/12	71 ± 120 (420)	-0.43 ± 1.3 (1.8)	0.91 ± 0.37 (1.4)
	07/19			
	08/13		NO SAMPLE - COW DRY	
	09/06			
	10/11	42 ± 150 (490)	-0.71 ± 1.7 (2.3)	0.96 ± 0.40 (1.5)
	11/07			
	12/05	380 ± 140 (480)	[b]	0.71 ± 0.40 (1.4)
PAHRUMP NV				
PAHRUMP DAIRY	01/02	-120 ± 120 (380)	[b]	0.71 ± 0.50 (1.7)
	02/06			
	03/02			
	04/02	-50 ± 120 (420)	[b]	0.39 ± 0.43 (1.6)
	05/01			
	06/04			
	07/17	-160 ± 120 (400)	-0.18 ± 2 (2.6)	0.36 ± 0.53 (1.9)
	08/06			
	09/04			
	10/01	170 ± 140 (480)	[b]	0.029 ± 0.40 (1.7)
	11/01			
	12/06			
SHOSHONE NV				
HARBECKE RANCH	01/08			
	02/05	280 ± 130 (420)	[b]	1.3 ± 0.46 (1.5)
	03/01			
	03/27			
	05/07	140 ± 130 (430)	-0.10 ± 1.6 (2.2)	1.8 ± 0.40 (1.4)[c]
	06/01			
	07/10			
	08/06	270 ± 110 (360)	-1.6 ± 2.2 (2.7)	2.1 ± 0.49 (1.6)[c]
	09/05			
	10/01			
	11/01	290 ± 160 (520)	0.16 ± 2.2 (2.7)	2.5 ± 0.52 (1.7)[c]
	12/04			
CEDAR CITY UT				
BRENT JONES DAIRY	01/03	190 ± 130 (420)	[b]	1.1 ± 0.39 (1.4)
	02/07			
	03/01			
	03/26	88 ± 130 (440)	[b]	0.55 ± 0.36 (1.5)
	05/01			
	06/01			
	07/02	-33 ± 130 (420)	0.25 ± 1.4 (2.0)	0.80 ± 0.36 (1.4)
	08/09			
	09/05			
	10/04	320 ± 150 (480)	2.7 ± 2.5 (3.4)	0.10 ± 0.50 (1.8)
	11/01			
	12/04			
IVINS UT				
DAVID HAFEN RANCH	01/04	100 ± 120 (410)	[b]	1 ± 0.42 (1.5)

(continued)

TABLE A2. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-9} μCi/mL)[a]	^{89}SR (10^{-9} μCi/mL)[a]	^{90}SR (10^{-9} μCi/mL)[a]
	02/08			
	03/02			
	03/26	310 ± 140 (450)	[b]	2.6 ± 0.48 (1.5)[c]
	05/02			
	06/01			
	07/02	-98 ± 130 (420)	-0.021 ± 1.3 (1.8)	0.84 ± 0.34 (1.3)
	08/06			
	09/07			
	10/04	270 ± 140 (460)	[b]	0.76 ± 0.49 (1.8)
	11/01			
	12/04			

[a] *Multiply by 3.7 x 10^{7} Bq/L to convert to Becquerals.*
[b] *Samples not analyzed.*
[c] *Concentration is greater than the minimum detectable concentration (MDC).*

Note: Where only collection dates are shown, samples were analyzed by gamma spectroscopy only.

TABLE A3. SUMMARY OF ANALYTICAL RESULTS FOR THE STANDBY MILK SURVEILLANCE NETWORK — 1990

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-9} µCi/mL)[a]	^{89}SR (10^{-9} µCi/mL)[a]	^{90}SR (10^{-9} µCi/mL)[a]
TAYLOR AZ SUNRISE DAIRY	07/31	280 ± 110 (370)	0.85 ± -0.93 (1.4)	-0.089 ± -0.32 (1.4)
TUCSON AZ UNIVERSITY OF ARIZONA	07/22	-64 ± 130 (430)	0.043 ± 0.92 (1.5)	0.34 ± 0.32 (1.4)
LITTLE ROCK AR BORDENS	07/01	-16 ± 130 (420)	-0.31 ± 1.3 (1.5)	3.2 ± 0.48 (1.4)[b]
RUSSELLVILLE AR ARKANSAS TECH. UNIV.	07/26	40 ± 110 (370)	0.71 ± 1.2 (1.5)	1.6 ± 0.41 (1.4)[b]
BAKERSFIELD CA FAVORITE FOODS, INC.	07/31	240 ± 120 (380)	-0.35 ± 0.80 (1.3)	0.59 ± 0.31 (1.3)
ORLAND CA MEADOW GLEN/JERSEYLAND CHEESE	08/01	270 ± 120 (380)	0.37 ± 0.96 (1.3)	0.69 ± 0.3 (1.3)
WILLOWS CA GLENN MILK PRODUCERS ASSN.	08/01	78 ± 110 (360)	0.41 ± 0.84 (1.3)	0.61 ± 0.33 (1.3)
CANON CITY CO JUNIPER VALLEY FARMS DAIRY	08/13	190 ± 110 (370)	1.3 ± 1.1 (1.3)	0.44 ± 0.42 (1.5)
DELTA CO MEADOW GOLD DAIRY	07/25	180 ± 110 (370)	0.24 ± 0.99 (1.5)	0.51 ± 0.33 (1.4)
QUINCY IL PRAIRIE FARMS DAIRY	07/31	240 ± 110 (360)	0.61 ± 0.93 (1.3)	0.81 ± 0.35 (1.4)
BOISE ID MEADOW GOLD DAIRIES	08/31	380 ± 110 (360)[b]	-1.2 ± 1.8 (2.6)	1.7 ± 0.45 (1.6)[b]
IDAHO FALLS ID REEDS DAIRY	08/29	120 ± 110 (370)	-1.5 ± 1.6 (2.5)	0.94 ± 0.39 (1.6)
DUBUQUE IA SWISS VALLEY FARMS, INC.	07/23	120 ± 130 (440)	0.83 ± 0.91 (1.1)	1.4 ± 0.41 (1.4)
ELLIS KS MID-AMERICA DAIRY	06/26	140 ± 130 (440)	0.43 ± 1.1 (1.5)	1.2 ± 0.39 (1.4)
SABETHA KS MID-AMERICA DAIRYMEN	06/19	440 ± 140 (440)	0.21 ± 1.1 (1.6)	1.2 ± 0.37 (1.4)
BATON ROUGE LA BORDEN'S	09/05	80 ± 110 (370)	-0.94 ± 1.9 (2.5)	2.2 ± 0.49 (1.6)[b]
MONROE LA BORDEN'S DAIRY	09/25	240 ± 120 (370)	[c]	0.67 ± 0.47 (1.8)

(continued)

TABLE A3. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-9} μCi/mL)[a]	^{89}SR (10^{-9} μCi/mL)[a]	^{90}SR (10^{-9} μCi/mL)[a]
NEW ORLEANS LA				
BROWN'S VELVET DAIRY	09/07	98 ± 110 (360)	[c]	2.6 ± 0.50 (1.5)[b]
FOSSTON MN				
LAND O' LAKES INC.	07/30	51 ± 110 (370)	0.70 ± 1.1 (1.4)	1 ± 0.38 (1.4)
ROCHESTER MN				
ASSOC. MILK PROD. INC. (AMPI)	08/15	270 ± 120 (380)	-2.3 ± 1.8 (2.3)	2.4 ± 0.47 (1.5)[b]
AURORA MO				
MID-AMERICA DAIRY INC.	07/24	72 ± 130 (420)	-1.3 ± 1.5 (1.8)	3.1 ± 0.51 (1.5)[b]
CHILLICOTHE MO				
MID-AMERICA DAIRYMEN	07/05	230 ± 130 (420)	-0.063 ± 1.1 (1.3)	2.1 ± 0.41 (1.4)[b]
BILLINGS MT				
MEADOW GOLD DAIRY	09/11	92 ± 120 (380)	-0.88 ± 1.7 (2.1)	1.8 ± 0.46 (1.5)[b]
HAVRE MT				
VITA-RICH DAIRY	09/10	240 ± 110 (370)	[c]	0.31 ± 0.45 (1.6)
NORFOLK NE				
GILLETTE DAIRY	06/06	24 ± 120 (410)	-1.2 ± 1.1 (1.4)	2.3 ± 0.39 (1.3)[b]
NORTH PLATTE NE				
MID-AMERICA DAIRYMEN	06/12	59 ± 130 (420)	0.87 ± 1.3 (1.3)	2.9 ± 0.47 (1.3)[b]
ALBUQUERQUE NM				
BORDEN'S VALLEY GOLD	10/29	240 ± 160 (530)	0.093 ± 1.2 (1.5)	0.78 ± 0.41 (1.5)
LA PLATA NM				
RIVER EDGE DAIRY	07/02	400 ± 140 (440)	-1 ± 0.87 (1.4)	0.79 ± 0.32 (1.4)
BISMARCK ND				
BRIDGEMAN CREAMERY, INC.	05/23	210 ± 130 (440)	-0.99 ± 1.6 (1.8)	2.2 ± 0.44 (1.4)[b]
GRAND FORKS ND				
MINNESOTA DAIRY	05/08	380 ± 140 (440)	1.8 ± 1.9 (2.8)	0.73 ± 0.36 (1.4)
ENID OK				
AMPI GOLDSPOT DIVISION	07/18	27 ± 130 (420)	0.19 ± 0.90 (1.1)	1.9 ± 0.40 (1.4)[b]
MCALESTER OK				
JACKIE BRANNON CORR. CTR.	07/12	87 ± 120 (410)	-0.85 ± 0.88 (1.2)	1.6 ± 0.36 (1.4)[b]
CORVALLIS OR				
SUNNY BROOK DAIRY	08/16	100 ± 110 (370)	-0.71 ± 1.8 (2.4)	1.2 ± 0.46 (1.6)
MEDFORD OR				
DAIRYGOLD FARMS	08/14	130 ± 110 (360)	0.83 ± 0.79 (1.1)	0.29 ± 0.34 (1.4)
TILLAMOOK OR				
TILLAMOOK CO. CREAMERY	10/19	220 ± 150 (480)	0.70 ± 1.4 (1.9)	0.56 ± 0.42 (1.5)

(continued)

TABLE A3. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1S.D. (MDC) ^{3}H (10^{-6} µCi/mL)[a]	^{89}SR (10^{-9} µCi/mL)[a]	^{90}SR (10^{-9} µCi/mL)[a]
RAPID CITY SD				
GILLETTE DAIRY-BLACK HILLS DAIRY	08/30	-110 ± 110 (360)	-2.3 ± 1.8 (2.6)	1.7 ± 0.44 (1.6)[b]
SIOUX FALLS SD				
LAND O'LAKES INC.	06/07	440 ± 140 (440)	-0.86 ± 1.1 (1.4)	1.7 ± 0.38 (1.4)[b]
BEAVER UT				
CACHE VALLEY DAIRY	07/18	-62 ± 130 (440)	-0.29 ± 0.82 (1.2)	0.67 ± 0.34 (1.4)
PROVO UT				
BYU DAIRY PRODUCTS LAB.	07/18	-4.7 ± 130 (420)	-0.25 ± 0.76 (1.1)	0.80 ± 0.33 (1.4)
SEATTLE WA				
DARIGOLD, INC.	10/24	150 ± 140 (440)	2 ± 1.7 (2.5)	-0.24 ± 0.47 (1.5)
SPOKANE WA				
DARIGOLD, INC.	08/28	2.5 ± 110 (370)	-1.7 ± 3.3 (5.1)	2 ± 0.79 (3)
SHERIDAN WY				
MIDLAND DAIRY	06/11	400 ± 140 (440)	-0.46 ± 1.4 (1.7)	2.4 ± 0.42 (1.4)[b]

[a]Multiply by 3.7 x 10^{7} Bq/Lto convert to Becquerals.
[b]Concentration is greater than the minimum detectable concentration (MDC).
[c]Samples not analyzed.

SAMPLING LOCATION	COLLECTION DATE 1990
SAMPLES FROM THE FOLLOWING LOCATIONS WERE ANALYZED BY GAMMA SPECTOSCOPY ONLY: (IN ALL CASES ONLY NATURALLY OCCURRING RADIONUCLIDES WERE DETECTED)	
DUNCAN AZ	
LUNT DAIRY	07/22
TEMPE AZ	
UNITED DAIRYMEN OF AZ	07/20
YUMA AZ	
RICHARD K. COMBS DAIRY	07/22
BATESVILLE AR	
HILLS VALLEY FOODS	07/05
FAYETTEVILLE AR	
UNIVERSITY OF ARKANSAS	07/11
HELENDALE CA	
OSTERKAMP DAIRY NO. 2	07/27
CHINO CA	
CA INST. FOR MEN	07/23
FERNBRIDGE CA	
HUMBOLDT CREAMERY ASSN.	07/25
FRESNO CA	
CA STATE UNIV. CREAMERY	10/22
HOLTVILLE CA	
SCHAFFNER & SON DAIRY	07/24
LOMPOC CA	
FEDERAL PENITENTIARY CAMP	07/31
MANTECA CA	
A & J FOODS, INC.	07/31
MODESTO CA	
FOSTER FARMS, JERSEY DAIRY	08/01
PETALUMA CA	
POINT REYES SEASHORE DAIRY	07/25
REDDING CA	
MCCOLL'S DAIRY PROD.	08/01

(continued)

TABLE A3. Continued

SAMPLING LOCATION	COLLECTION DATE 1990
SAN JOSE CA	
MARQUEZ BROS. MEXICAN CHEESE	07/26
SAN LUIS OBISPO CA	
CAL POL. UNIV. DAIRY	07/25
SAUGUS CA	
WAYSIDE HONOR RANCH	07/27
CRESENT CITY CA	
RUMIANO CHEESE CO.	07/23
SOLEDAD CA	
CORRECTION TRAINING INST.	10/24
TRACY CA	
DEUEL VOC. INST.	07/31
MANCHESTER CA	
POINT ARENA DAIRIES	07/25
COLORADO SPRINGS CO	
SINTON DAIRY CO.	07/12
GREELEY CO	
MEADOW GOLD DAIRY	08/29
DENVER CO	
SAFEWAY DAIRY PLANT	07/24
FT COLLINS CO	
POUDRE VALLEY CREAMERY	11/08
CALDWELL ID	
DAIRYMENS CREAMERY ASSN.	09/06
POCATELLO ID	
ROWLAND'S MEADOW GOLD DRY	08/29
KIMBALLTON IA	
ASSOC. MILK PRO. INC. (AMPI)	07/23
LAKE MILLS IA	
LAKE MILLS COOP. CREAMERY	07/25
LEMARS IA	
WELLS DAIRY	07/24
MANHATTAN KS	
KANSAS STATE UNIVERSITY	06/12
LAFAYETTE LA	
BORDEN'S	09/05
NEW ORLEANS LA	
WALKER ROEMER DAIRY	09/07
SHREVEPORT LA	
FOREMOST DAIRY	09/14
FERGUS FALLS MN	
MID-AMERICA DAIRYMEN	08/30
BROWERVILLE MN	
LAND O' LAKES, INC.	08/28
NICOLLET MN	
DOUG SCHULTZ FARM	08/08
JACKSON MO	
MID-AMERICA DAIRYMEN	09/17
JEFFERSON CITY MO	
CENTRAL DAIRY CO.	09/14
BOZEMAN MT	
COUNTRY CLASSIC-DBA-DARIGOLD	09/10
GREAT FALLS MT	
MEADOW GOLD DAIRY	09/10
KALISPELL MT	
EQUITY SUPPLY CO.	09/06
OMAHA NE	
ROBERTS DAIRY-MARSHALL GR.	06/21
CHAPPELL NE	
LEPRINO FOODS	07/30
SUPERIOR NE	
MID-AMERICA DAIRYMEN	06/13
FALLON NV	
CREAMLAND DAIRY	07/23
LOGANDALE NV	
NEVADA DAIRY	08/29
RENO NV	
MODEL DAIRY	07/23
YERINGTON NV	
VALLEY DAIRY	07/23
DEVILS LAKE ND	
LAKE VIEW DAIRY	05/07

(continued)

TABLE A3. Continued

SAMPLING LOCATION	COLLECTION DATE 1990
FARGO ND	
CASS CLAY CREAMERY	05/07
CLAREMORE OK	
SWAN BROS. DAIRY	07/24
STILLWATER OK	
OK STATE UNIV. DAIRY	10/29
GRANTS PASS OR	
VALLEY OF ROUGE DAIRY	08/14
KLAMATH FALLS,OR	
KLAMATH DAIRY PRODUCT	08/09
COVE OR	
SUNNY COVE DAIRY	08/13
MYRTLE POINT OR	
SAFEWAY STORES INC.	08/14
REDMOND OR	
EBERHARD'S CREAMERY INC.	08/13
ETHAN SD	
ETHAN DAIRY PRODUCTS	08/31
OGDEN UT	
WESTERN DAIRYMEN COOP.	09/13
RICHFIELD UT	
IDEAL DAIRY	06/22
SMITHFIELD UT	
CACHE VALLEY DAIRY	06/23
MOSES LAKE WA	
SAFEWAY STORES INC.	08/29
CHEYENNE WY	
DAIRY GOLD FOODS	09/10
RIVERTON WY	
WESTERN DAIRYMAN COOP.	06/11
THAYNE WY	
WESTERN DAIRYMEN COOP.	06/13

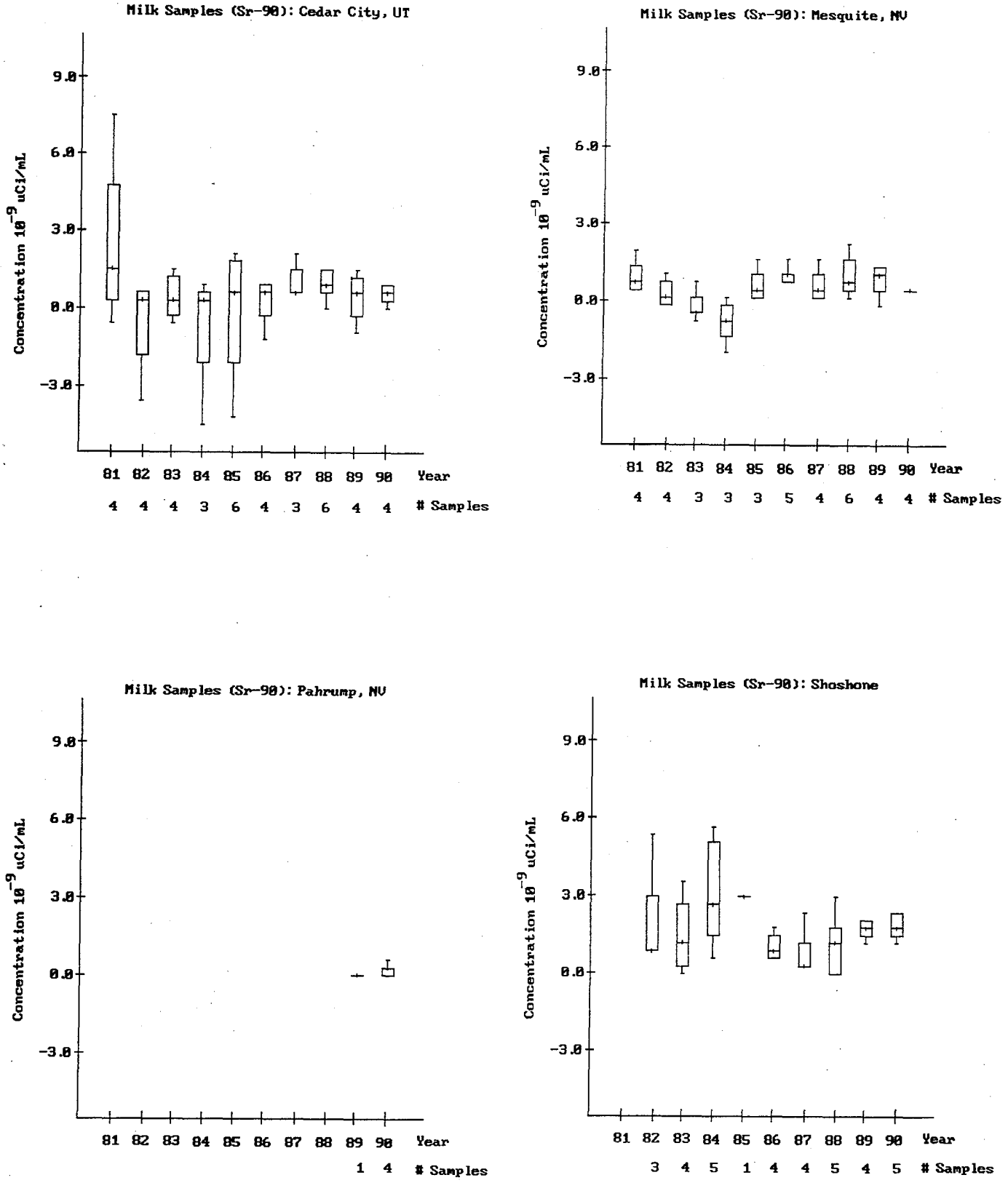


Figure A3. Historical ^{90}Sr trends in milk samples - monthly averages.

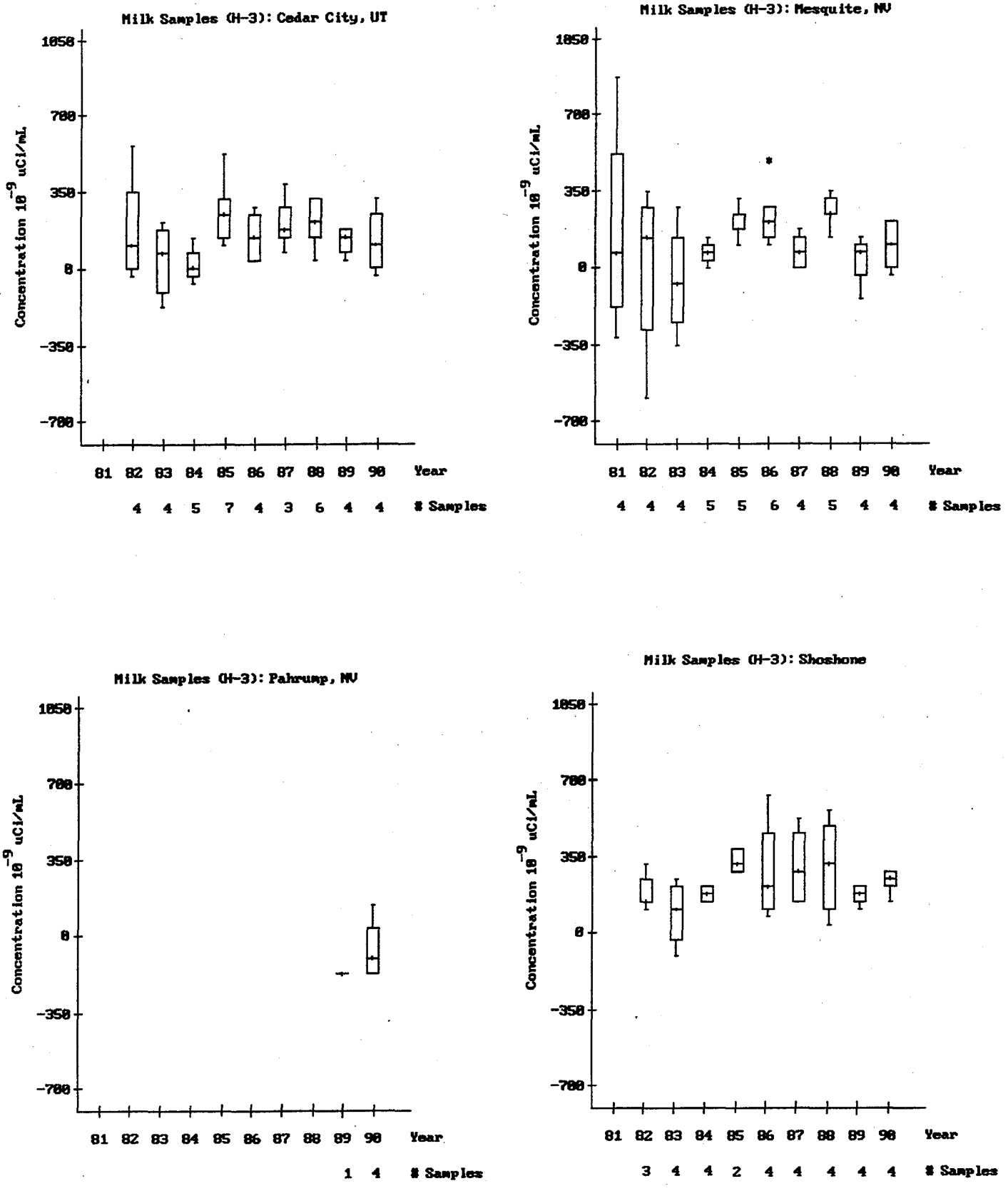
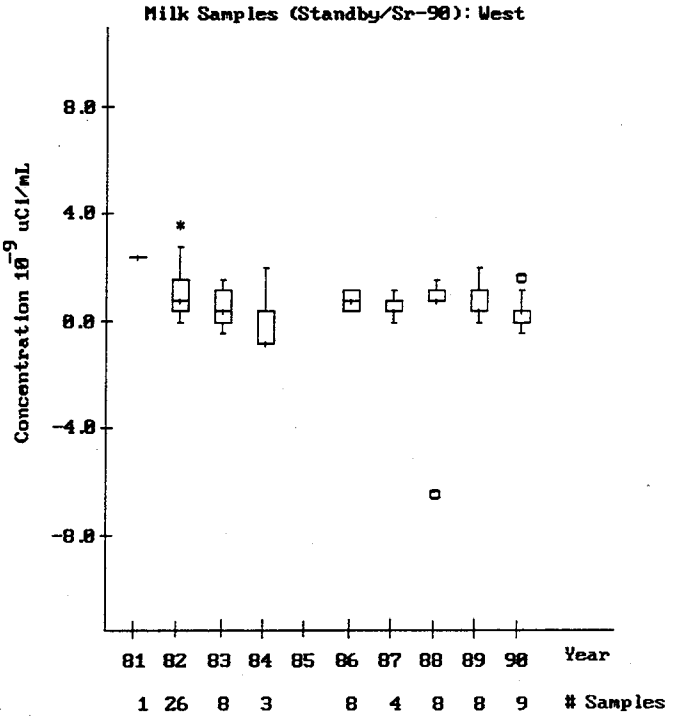
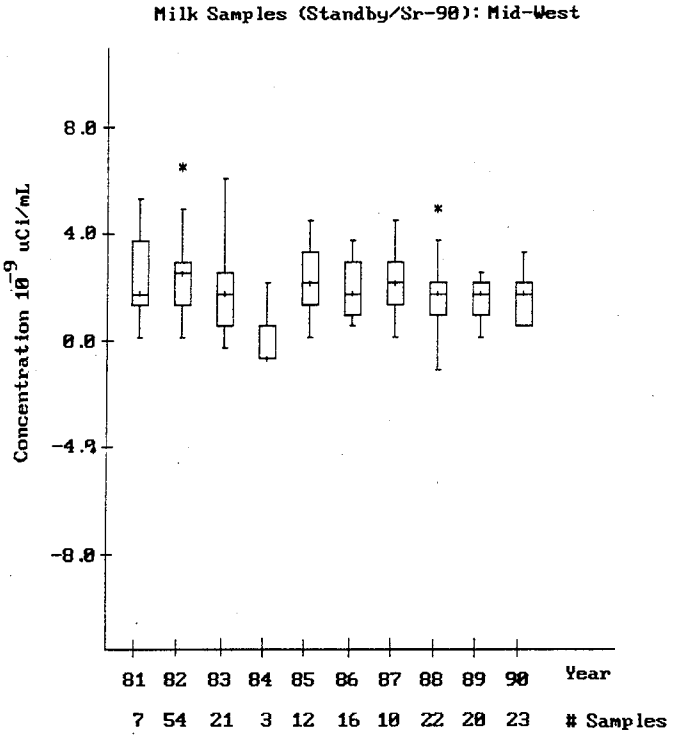
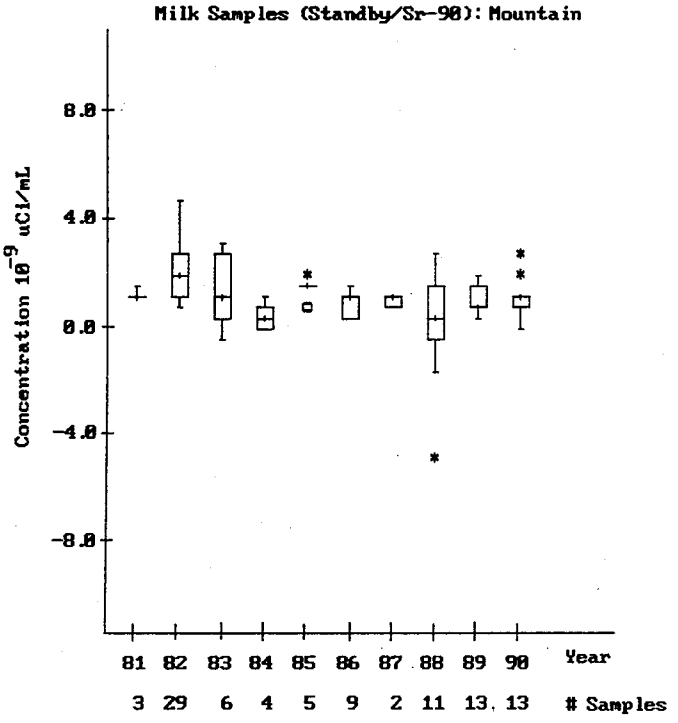


Figure A4. Historical ^{3}H trends in milk samples - monthly averages.







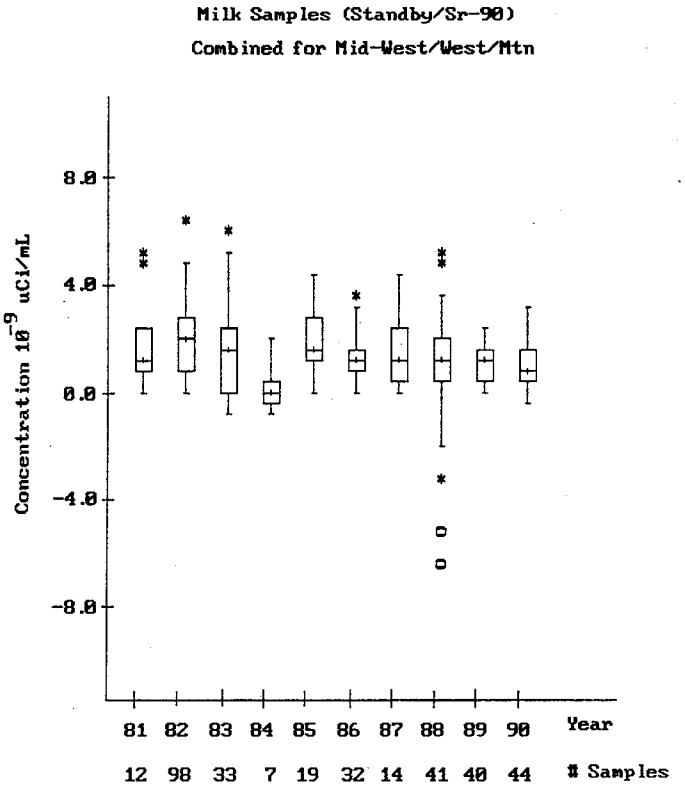


Figure A5. Historical ^{90}Sr trends in standby milk samples - monthly averages.

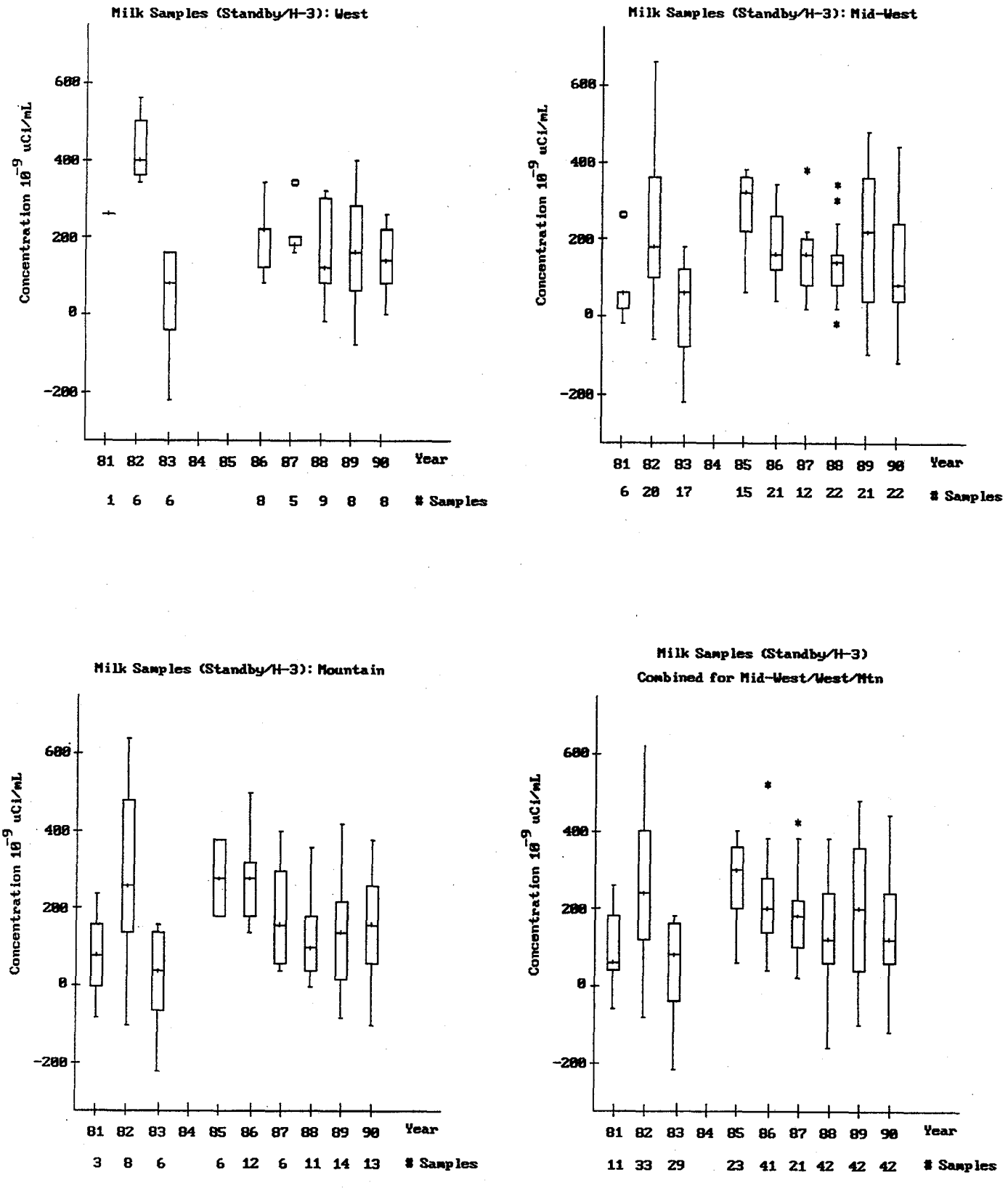


Figure A6. Historical ^{3}H trends in standby milk samples - monthly averages.

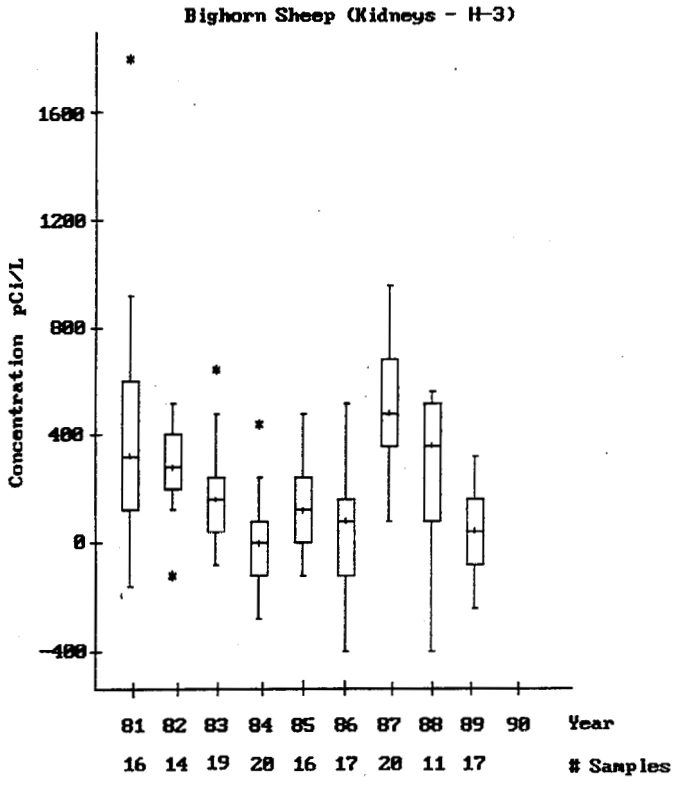


Figure A7. ^{3}H concentrations in desert bighorn sheep kidneys, 1981-1989.

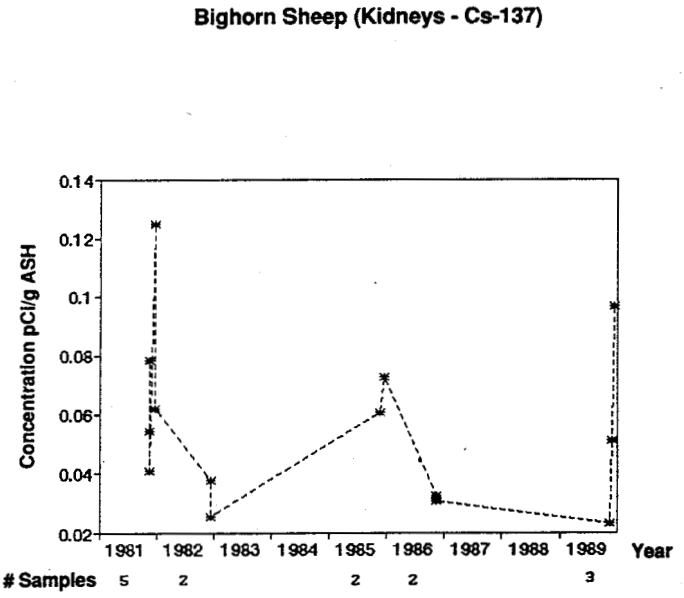


Figure A8. ^{137}Cs concentrations in desert bighorn sheep kidneys, 1981-1989.

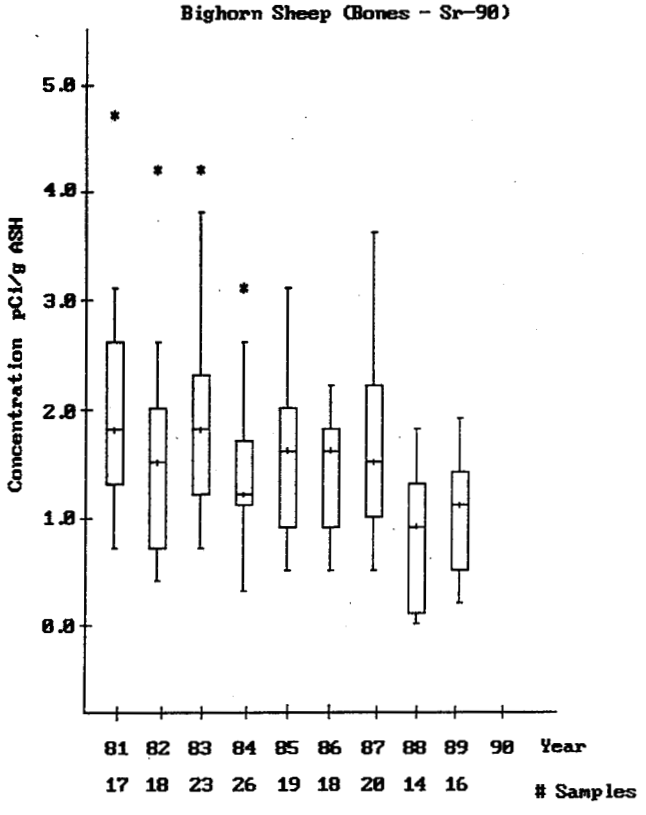


Figure A9. ^{90}Sr concentrations in desert bighorn sheep bones, 1981-1989.

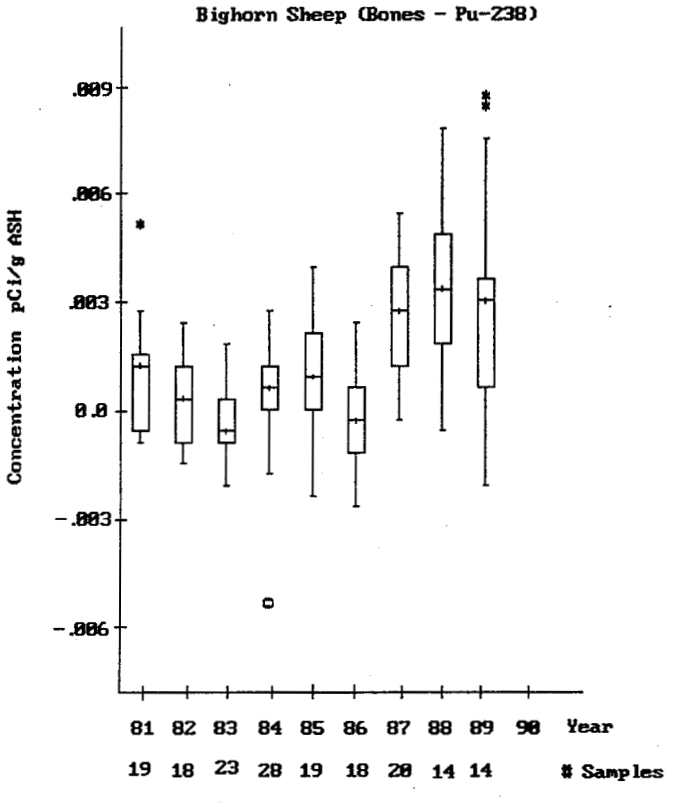


Figure A10. ^{238}Pu concentrations in desert bighorn sheep bones, 1981-1989.

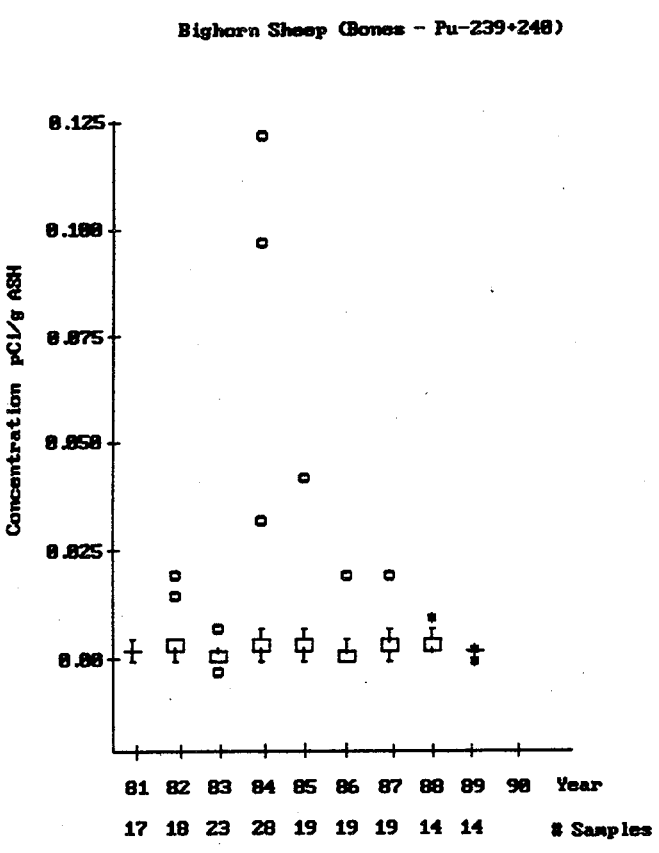


Figure A11. $^{239+240}$Pu concentrations in desert bighorn sheep bones, 1981-1989.

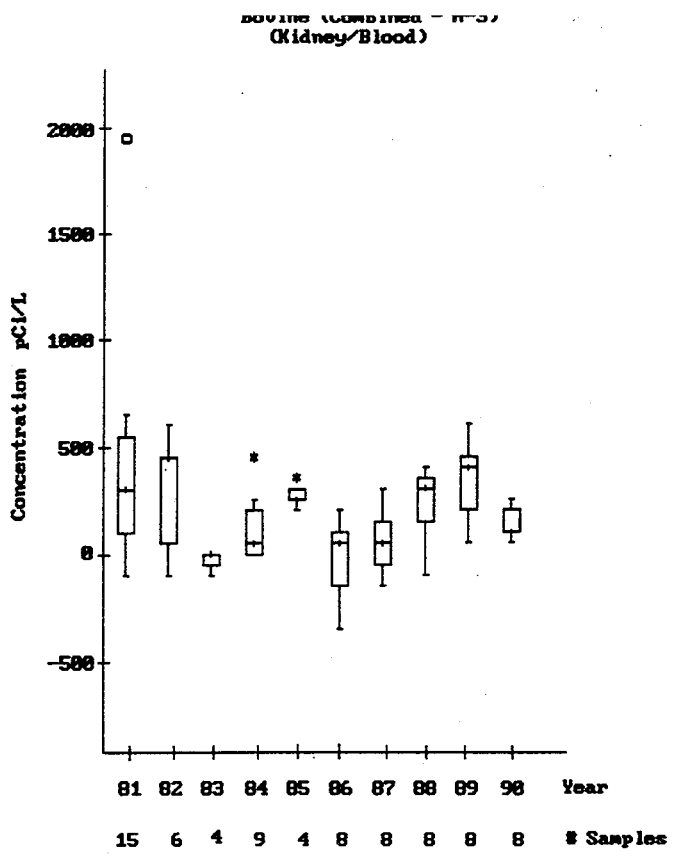


Figure A12. ^{3}H concentrations in cattle tissue, 1981-1990.

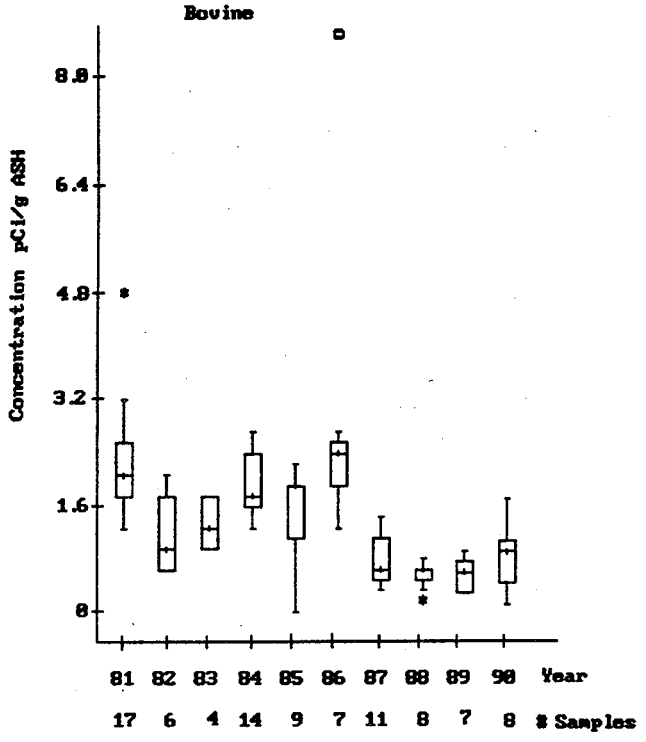


Figure A13. ^{90}Sr concentrations in cattle bones, 1981-1990.

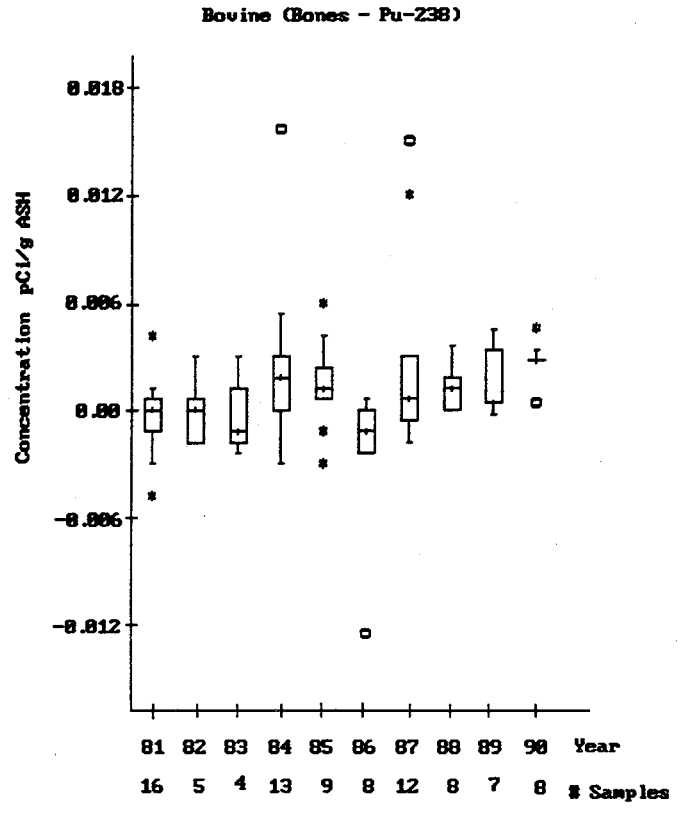


Figure A14. ^{238}Pu concentrations in cattle bones, 1981-1990.

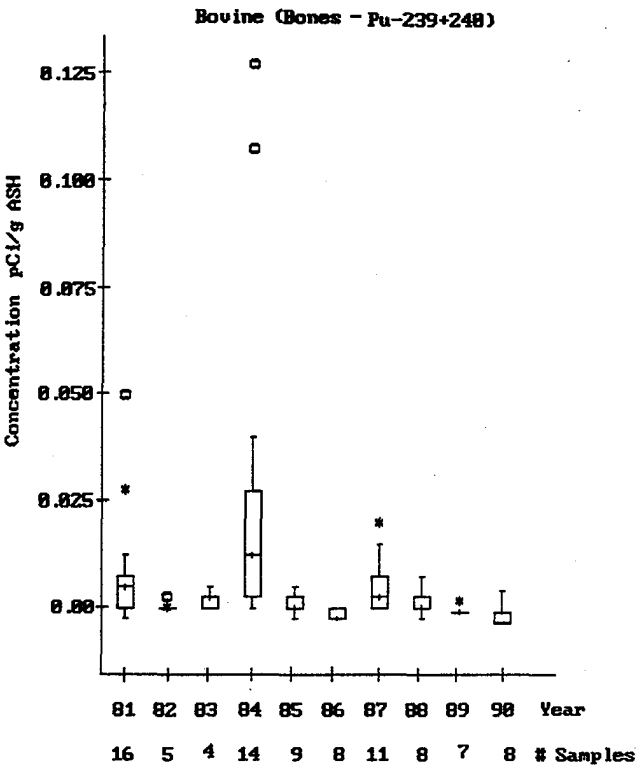


Figure A15. $^{239+240}$Pu concentrations in cattle bones, 1981-1990.

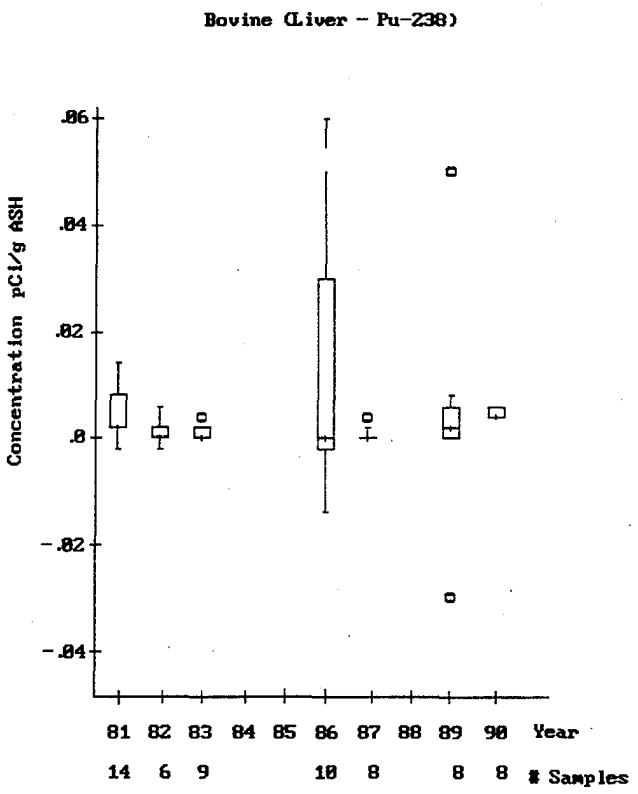


Figure A16. ^{238}Pu concentrations in bovine liver, 1981-1990.

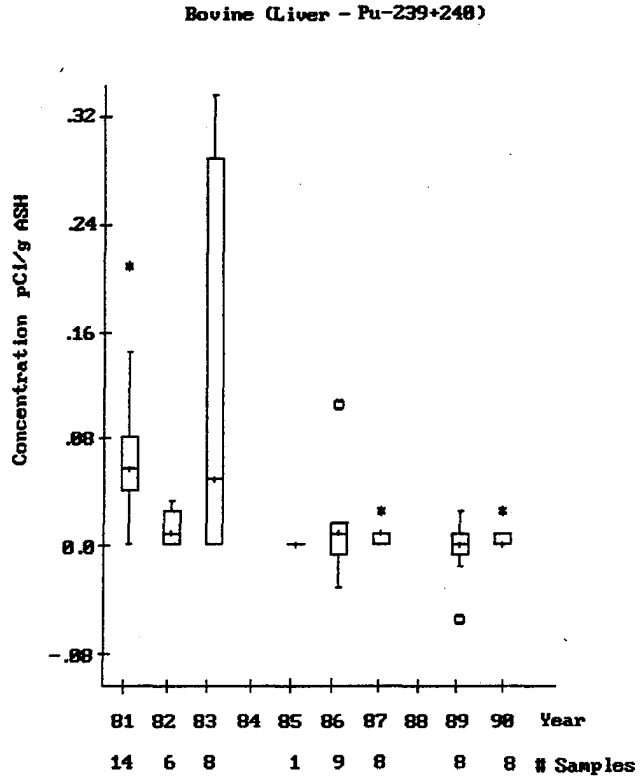


Figure A17. $^{239+240}$Pu concentrations in bovine liver, 1981-1990.

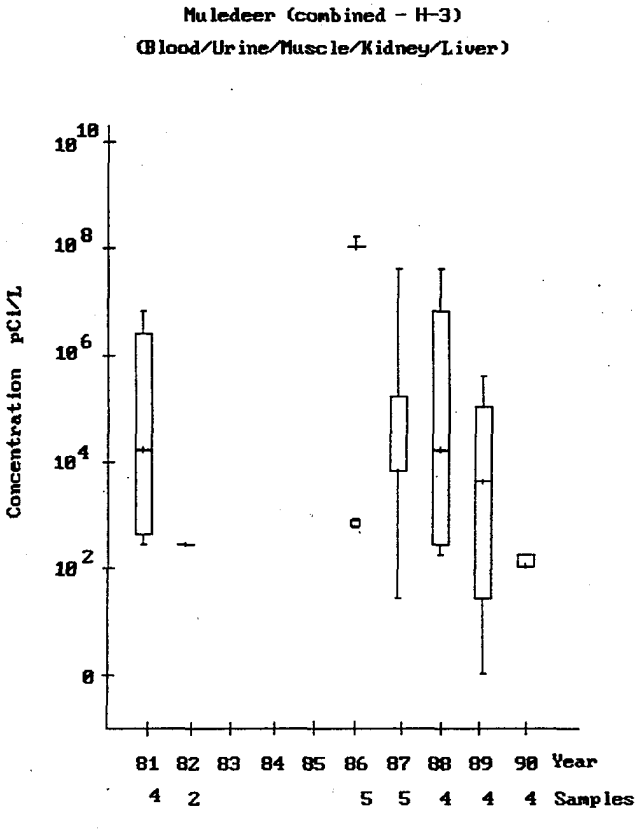


Figure A18. ^{3}H concentrations in mule deer selected tissues, 1981-1990.

TABLE A4. THERMOLUMINESCENT DOSIMETER RESULTS FOR OFFSITE PERSONNEL — 1990

REFERENCE IDENTIFICATION NUMBER	ASSOCIATED REFERENCE BACKGROUND LOCATION	MEASUREMENT PERIOD ISSUE DATE	COLLECT DATE	TIME PERIOD (days)	NUMBER OF DATA POINTS	EQUIVALENT DOSE RATE (mrem/day) MAX	MIN	MEAN	DOSE (mrem/yr)[a]	ANNUAL ASSOCIATED MEASURED REFERENCE BACKGROUND EXPOSURE (mR/yr)
Arizona										
	No individuals residing in Arizona were monitored during the period covered by this report									
California										
304	Death Valley Jct.	01/05/90	01/09/91	369	12	0.45	0.22	0.35	128	69
359	Death Valley Jct.	01/04/90	01/10/91	370	12	0.32	0.09	0.21	77	69
60	Shoshone	01/02/90	01/08/91	371	12	0.88	0.02	0.28	103	50
404	Shoshone	04/02/90	01/16/91	289	9	0.83	0.08	0.34	98	51
Nevada										
22	Alamo	01/10/90	01/03/91	358	11	0.30	0.09	0.17	62	67
426	Amargosa Comm. Center	01/10/90	01/16/91	370	12	0.39	0.02	0.26	95	99
21	Beatty	01/04/90	01/10/91	370	10	0.45	0.05	0.22	80	96
38	Beatty	01/04/90	01/09/91	370	12	0.54	0.17	0.31	115	95
358	Beatty	01/04/90	01/11/91	372	11	5.40	0.11	0.75	280	95
37	Indian Springs	01/02/90	01/07/91	370	12	0.42	0.02	0.12	44	28
405	Indian Springs	04/02/90	01/07/91	279	9	0.28	0.08	0.17	46	28
381	Ione	01/09/90	01/15/91	371	10	0.58	0.03	0.24	88	76
00	Koyne's Ranch	01/09/90	01/03/91	359	11	0.24	0.02	0.12	43	67
49	Las Vegas (UNLV)	01/02/90	01/02/91	364	11	0.25	0.02	0.11	41	14
297	Las Vegas (USDI)	01/02/90	01/02/91	365	12	0.30	0.01	0.10	37	35
326	Las Vegas (USDI)	01/02/90	01/02/91	365	12	0.20	0.00	0.09	34	35
376	Las Vegas (USDI)	01/02/90	01/02/91	365	12	0.19	0.02	0.09	31	35
377	Las Vegas (USDI)	01/02/90	01/02/91	365	12	0.21	0.02	0.10	36	35
398	Las Vegas (USDI)	03/05/90	01/02/91	303	10	0.99	0.09	0.32	95	35
399	Las Vegas (USDI)	03/05/90	01/02/91	302	10	0.29	0.03	0.14	42	35
400	Las Vegas (USDI)	03/05/90	11/06/90	245	8	0.26	0.01	0.13	32	35
401	Las Vegas (USDI)	03/05/90	11/06/90	246	8	0.79	0.04	0.26	64	35
402	Las Vegas (USDI)	03/05/90	01/02/91	303	10	0.81	0.03	0.29	89	35
403	Las Vegas (USDI)	03/05/90	01/02/91	302	10	0.97	0.02	0.25	76	35
342	Lavada's Market	01/04/90	10/11/90	280	9	0.24	0.09	0.17	49	72
380	Lavada's Market	01/04/90	01/03/91	364	11	0.32	0.00	0.19	68	76
379	Manhattan	01/10/90	01/16/91	371	12	0.52	0.01	0.22	81	100
307	Mina	01/09/90	01/15/91	371	12	0.39	0.04	0.20	73	69
18	Nyala	01/03/90	01/03/91	364	12	0.39	0.04	0.18	64	63
348	Overton	01/04/90	01/02/91	363	12	0.27	0.05	0.16	57	56
36	Pahrump	01/02/90	07/17/90	195	6	0.38	0.11	0.21	40	27
372	Pahrump	01/02/90	01/03/91	366	11	0.28	0.04	0.15	55	27
410	Pahrump	04/02/90	01/08/91	280	9	2.45	0.02	0.41	114	28
411	Pahrump	04/02/90	01/08/91	280	9	0.37	0.03	0.19	54	28
248	Penoyer Farms	01/09/90	01/03/91	358	11	0.37	0.13	0.21	74	92
293	Pioche	01/08/90	01/02/91	359	11	0.32	0.10	0.21	76	60
264	Rachel	01/09/90	01/04/91	360	11	0.54	0.16	0.27	98	85
334	Rachel	01/09/90	01/03/91	358	11	0.35	0.08	0.20	72	85
299	Round Mountain	01/10/90	01/16/91	370	12	0.35	0.03	0.21	78	80
341	Silver Peak	01/17/90	01/17/91	365	12	0.34	0.04	0.19	69	61
29	Stone Cabin Ranch	01/03/90	01/03/91	365	12	0.55	0.10	0.34	122	92
42	Tonopah	01/19/90	01/17/91	362	12	4.11	0.04	0.54	196	87

(continued)

TABLE A4. Continued

REFERENCE IDENTIFICATION NUMBER	ASSOCIATED REFERENCE BACKGROUND LOCATION	MEASUREMENT PERIOD ISSUE DATE	COLLECT DATE	TIME PERIOD (days)	NUMBER OF DATA POINTS	EQUIVALENT DOSE RATE (mrem/day) MAX	MIN	MEAN	DOSE (mrem/yr)[a]	ANNUAL ASSOCIATED MEASURED REFERENCE BACKGROUND EXPOSURE (mR/yr)
339	Tonopah	01/11/90	01/17/91	371	12	0.60	0.04	0.28	105	87
370	Twin Springs Ranch	01/03/90	01/03/91	365	12	0.38	0.11	0.25	90	95
424	Yucca-Halloway Ranch	11/15/90	01/10/91	56	2	0.29	0.22	0.25	14	104
Utah										
44	Cedar City	01/04/90	01/02/91	363	11	0.34	0.05	0.17	62	43
344	Delta	01/08/90	01/02/91	359	12	0.93	0.04	0.24	85	59
345	Delta	01/08/90	01/02/91	359	12	0.58	0.05	0.24	85	59
347	Milford	01/08/90	01/02/91	358	12	0.62	0.05	0.26	92	89
346	Milford	01/08/90	01/02/91	358	12	0.84	0.04	0.24	87	89
52	Salt Lake City	01/03/90	01/02/91	364	12	0.29	0.04	0.17	60	45
445	St. George	01/04/90	01/02/91	362	12	0.51	0.03	0.15	53	33

[a]Annual dose (mrem/yr) is calculated by multiplying the average (mean) equivalent dose rate (mrem/day) by 365.25.

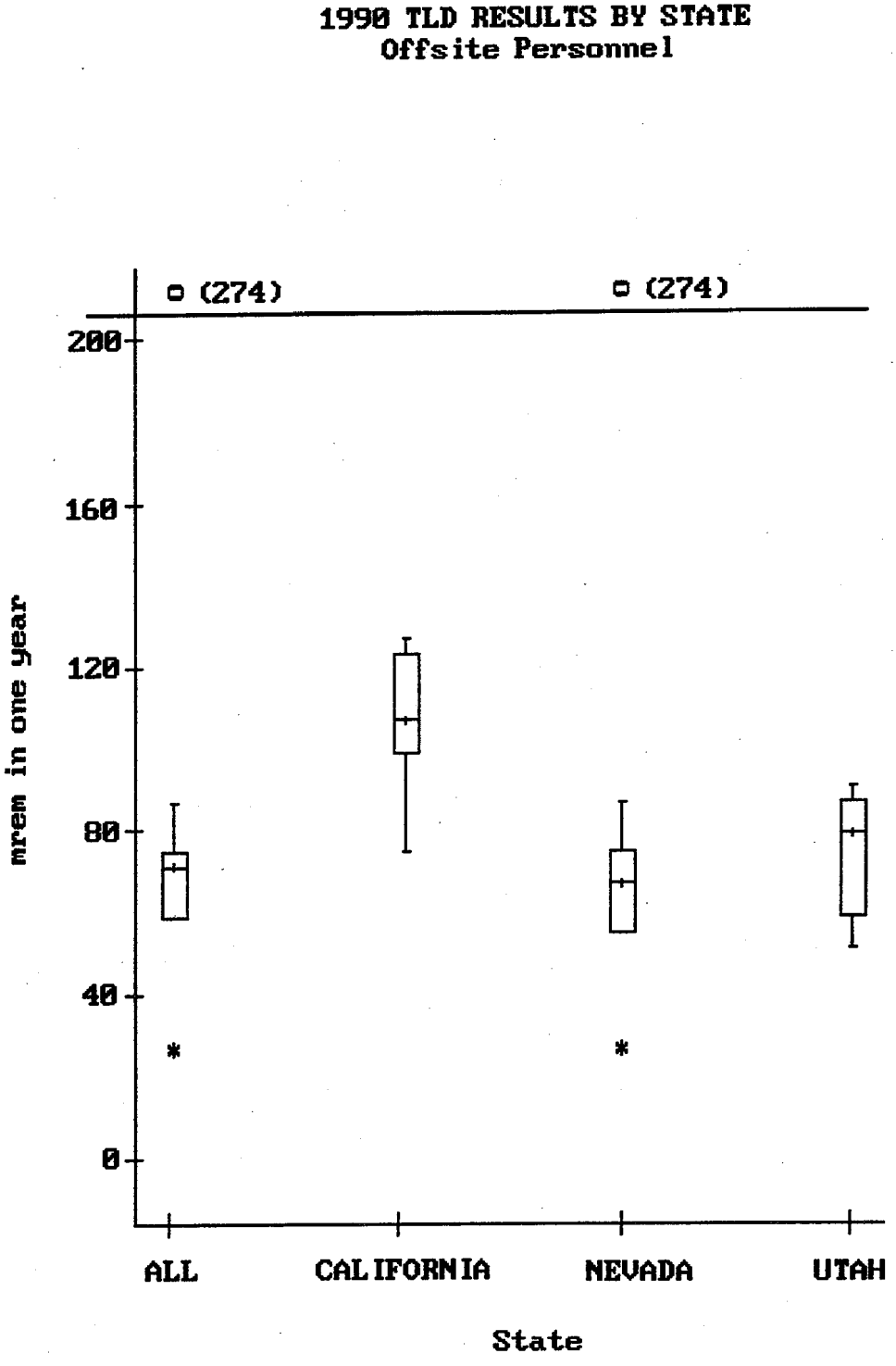


Figure A19. Thermoluminescent dosimeter monitoring results for offsite residents.

TABLE A5. THERMOLUMINESCENT DOSIMETER RESULTS FOR OFFSITE STATIONS — 1990

STATION LOCATION	MEASUREMENT ISSUE DATE	PERIOD COLLECT DATE	ELAPSED TIME IN PERIOD (days)	NUMBER OF DATA POINTS	EQUIVALENT EXPOSURE RATE (mR/day) MAX	MIN	MEAN	EQUIVALENT EXPOSURE (mR/yr)[a]
Arizona								
Colorado City	11/06/89	10/30/90	358	4	0.20	0.13	0.15	53
Jacob's Lake	11/06/89	10/30/90	358	4	0.27	0.18	0.22	81
Page	11/07/89	10/31/90	357	4	0.17	0.11	0.13	47
California								
Baker	11/07/89	11/01/90	359	4	0.22	0.18	0.20	72
Barstow	11/07/89	11/01/90	358	4	0.29	0.21	0.25	90
Bishop	11/14/89	11/03/90	353	4	0.28	0.20	0.24	88
Death Valley Jct.	01/05/90	01/09/91	369	4	0.24	0.14	0.20	74
Furnace Creek	01/05/90	01/09/91	368	4	0.19	0.14	0.17	61
Independence	11/08/89	11/02/90	359	4	0.25	0.17	0.21	78
Lone Pine	11/08/89	11/02/90	359	4	0.25	0.18	0.21	77
Mammoth Geothermal	11/14/89	11/03/90	353	4	0.30	0.21	0.26	93
Mammoth Lakes	11/14/89	11/03/90	353	3	0.30	0.20	0.26	94
Olancha	11/08/89	11/02/90	359	4	0.25	0.18	0.22	80
Ridgecrest	11/08/89	11/02/90	358	4	0.25	0.16	0.20	72
Shoshone	11/07/89	11/01/90	358	4	0.19	0.13	0.16	57
Valley Crest	01/05/90	01/09/91	368	4	0.13	0.09	0.11	39
Nevada								
Alamo	11/01/89	10/30/90	363	4	0.25	0.18	0.21	75
Amargosa Comm Ctr.	01/04/90	11/27/90	327	4	0.20	0.17	0.19	68
Amargosa Valley	01/02/90	01/14/91	377	4	0.25	0.24	0.24	89
American Borate	01/02/90	01/14/91	377	4	0.32	0.25	0.29	105
Atlanta Mine	12/01/89	12/04/90	368	4	0.23	0.14	0.18	66
Austin	11/08/89	11/07/90	363	3	0.31	0.26	0.29	107
Battle Mountain	12/13/89	11/28/90	350	4	0.22	0.14	0.18	64
Beatty	01/04/90	01/09/91	370	4	0.35	0.27	0.30	111
Blue Eagle Ranch	01/03/90	01/08/91	369	4	0.19	0.13	0.16	59
Blue Jay	01/04/90	01/08/91	368	4	0.38	0.31	0.33	122
Cactus Springs	11/06/89	11/01/90	359	4	0.14	0.08	0.10	37
Caliente	11/01/89	10/29/90	361	4	0.26	0.19	0.21	78
Carp	11/01/89	10/29/90	361	4	0.24	0.16	0.19	70
Cherry Creek	11/29/89	12/05/90	370	4	0.30	0.18	0.23	84
Clark Station	01/03/90	01/08/91	369	4	0.32	0.28	0.30	109
Coaldale	11/07/89	11/06/90	364	3	0.26	0.22	0.24	88
Complex 1	11/01/89	10/31/90	363	4	0.31	0.22	0.27	97
Corn Creek	11/06/89	11/01/90	359	4	0.10	0.05	0.07	25
Cortez Rd/Hwy 278	12/12/89	11/28/90	350	4	0.32	0.21	0.25	92
Coyote Summit	11/01/89	10/30/90	362	4	0.36	0.24	0.30	109
Crescent Valley	12/12/89	11/28/90	351	4	0.22	0.15	0.18	66
Currant	01/04/90	01/09/91	370	4	0.29	0.26	0.28	100
Currie	11/29/89	12/05/90	371	4	0.31	0.20	0.25	90
Diablo Maint Sta.	01/05/90	01/03/91	362	4	0.39	0.32	0.35	128
Duckwater	01/04/90	01/08/91	369	4	0.28	0.23	0.25	91
Elgin	11/01/89	10/29/90	361	4	0.37	0.24	0.30	110
Elko	12/12/89	11/27/90	350	4	0.20	0.13	0.16	57
Ely	11/29/89	12/05/90	370	4	0.22	0.13	0.17	61
Eureka	01/04/90	01/15/91	375	4	1.97	0.24	0.70	254
Fallon	12/13/89	11/29/90	350	4	0.26	0.11	0.17	63

(continued)

TABLE A5. Continued

STATION LOCATION	MEASUREMENT ISSUE DATE	PERIOD COLLECT DATE	ELAPSED TIME IN PERIOD (days)	NUMBER OF DATA POINTS	EQUIVALENT EXPOSURE RATE (mR/day) MAX	MIN	MEAN	EQUIVALENT EXPOSURE (mR/yr)*
Flying Diamond Camp	11/01/89	10/31/90	363	4	0.21	0.13	0.17	61
Gabbs	11/07/89	11/06/90	364	3	0.15	0.14	0.15	54
Geyser Ranch	12/01/89	12/04/90	368	4	0.29	0.18	0.22	82
Goldfield	11/09/89	11/13/90	368	3	0.22	0.19	0.21	76
Groom Lake	11/13/89	11/14/90	366	4	0.23	0.15	0.19	68
Hancock Summit	11/01/89	11/01/90	364	4	0.42	0.27	0.34	125
Hiko	11/01/89	10/30/90	362	4	0.19	0.12	0.15	55
Hot Creek Ranch	01/04/90	01/08/91	369	4	0.25	0.21	0.23	84
Indian Springs	11/06/89	11/01/90	359	4	0.12	0.07	0.09	32
Ione	11/07/89	11/06/90	363	3	0.24	0.20	0.22	82
Kirkeby Ranch	12/01/89	12/04/90	367	4	0.22	0.13	0.16	58
Koyne's Ranch	11/01/89	11/01/90	364	4	0.26	0.17	0.21	78
Las Vegas Airport	01/02/90	01/02/91	364	4	0.10	0.04	0.07	25
Las Vegas (UNLV)	01/02/90	01/02/91	365	4	0.09	0.02	0.05	19
Las Vegas (USDI)	01/02/90	01/02/91	365	3	0.16	0.08	0.12	45
Lavada's Market	01/04/90	01/14/91	375	4	0.29	0.22	0.26	96
Lida	11/01/89	11/13/90	376	3	0.24	0.20	0.22	82
Lovelock	12/13/89	11/28/90	349	4	0.21	0.11	0.16	57
Lund	11/30/89	12/06/90	371	4	0.23	0.13	0.18	66
LV Airport - Test	01/02/90	01/02/91	364	4	0.18	0.01	0.11	39
LV (USDI) - Test	01/02/90	01/02/91	365	4	0.10	0.01	0.07	26
Manhattan	11/08/89	11/07/90	364	3	0.32	0.27	0.29	107
Medlin's Ranch	11/01/89	11/01/90	365	4	0.31	0.22	0.26	97
Mesquite	11/02/89	10/29/90	360	4	0.15	0.11	0.12	45
Mina	11/07/89	11/06/90	363	3	0.23	0.18	0.21	75
Moapa	11/02/89	10/29/90	360	4	0.53	0.15	0.27	98
Mtn. Meadows Ranch	01/03/90	01/03/91	364	4	0.19	0.15	0.17	61
Nash Ranch	11/01/89	10/30/90	363	4	0.22	0.15	0.18	67
Nevada LLW Site	01/04/90	01/10/91	371	4	0.32	0.28	0.30	109
Nyala	01/03/90	01/03/91	364	4	0.23	0.18	0.20	74
Overton	11/02/89	10/29/90	361	4	0.44	0.11	0.21	75
Pahrump	11/06/89	11/01/90	359	4	0.11	0.06	0.09	31
Penoyer Farms	11/01/89	10/31/90	363	4	0.35	0.23	0.29	106
Pine Creek Ranch	11/01/89	10/31/90	363	4	0.35	0.25	0.30	111
Pioche	11/01/89	10/29/90	361	4	0.21	0.16	0.18	66
Queen City Summit	01/05/90	01/03/91	362	4	0.37	0.33	0.35	129
Rachel	11/01/89	10/31/90	363	4	0.30	0.21	0.26	94
Reed Ranch	01/05/90	01/03/91	362	4	0.33	0.29	0.31	115
Reno	12/14/89	11/29/90	349	4	0.20	0.12	0.15	56
Round Mountain	11/08/89	11/07/90	363	3	0.29	0.23	0.26	94
Ruby Valley	12/12/89	11/27/90	349	4	0.32	0.19	0.24	89
S. Desert Corr. Ctr.	11/06/89	11/01/90	359	4	0.11	0.06	0.08	31
Shurz	12/14/89	11/29/90	349	4	0.30	0.17	0.21	78
Silver Peak	11/07/89	11/13/90	371	3	0.17	0.14	0.16	57
Springdale	01/04/90	01/11/91	371	4	0.37	0.27	0.30	111
Steward Ranch	12/01/89	12/04/90	368	4	0.31	0.20	0.27	97
Stone Cabin Ranch	01/03/90	01/03/91	364	4	0.32	0.28	0.30	109
Sunnyside	11/30/89	12/06/90	371	4	0.15	0.08	0.11	39
Tempiute	11/01/89	11/01/90	365	4	0.30	0.22	0.27	98
Tonopah Test Range	01/04/90	01/02/91	362	4	0.35	0.31	0.33	120
Tonopah	11/08/89	11/07/90	363	3	0.29	0.24	0.26	95
Twin Springs Ranch	01/03/90	01/03/91	365	4	0.33	0.27	0.30	110
Uhalde's Ranch	11/01/89	10/31/90	363	4	0.32	0.21	0.27	99
US Ecology	01/04/90	01/11/91	372	4	0.33	0.29	0.31	115
Warm Springs #1	01/03/90	01/03/91	365	4	0.45	0.35	0.38	139

(continued)

TABLE A5. Continued

STATION LOCATION	MEASUREMENT ISSUE DATE	PERIOD COLLECT DATE	ELAPSED TIME IN PERIOD (days)	NUMBER OF DATA POINTS	EQUIVALENT EXPOSURE RATE (mR/day) MAX	MIN	MEAN	EQUIVALENT EXPOSURE (mR/yr)[a]
Warm Springs #2	01/03/90	01/03/91	365	3	1.12	0.99	1.07	390
Wells	12/12/89	11/27/90	349	4	0.24	0.14	0.18	67
Winnemucca	12/13/89	11/28/90	349	4	0.24	0.15	0.19	68
Young's Ranch	11/08/89	11/07/90	363	4	0.22	0.09	0.17	60
Utah								
Boulder	12/01/89	12/05/90	369	4	0.23	0.15	0.18	66
Bryce Canyon	12/01/89	12/05/90	369	4	0.21	0.13	0.16	58
Cedar City	12/04/89	11/28/90	359	4	0.18	0.11	0.14	51
Delta	01/08/90	01/30/91	387	4	0.21	0.17	0.19	70
Duchesne	01/10/90	01/29/91	383	4	0.18	0.14	0.16	58
Enterprise	12/01/89	11/27/90	360	4	0.36	0.23	0.29	105
Ferron	01/10/90	01/29/91	384	4	0.18	0.14	0.16	57
Garrison	11/29/89	12/05/90	371	4	0.21	0.12	0.16	57
Grantsville	01/09/90	01/30/91	385	4	0.19	0.14	0.17	61
Green River	11/07/89	10/31/90	358	4	0.20	0.14	0.16	57
Gunnison	12/01/89	12/06/90	369	4	0.15	0.11	0.13	46
Ibapah	11/29/89	12/05/90	371	4	0.27	0.19	0.23	85
Kanab	11/06/89	10/30/90	358	4	0.15	0.10	0.12	42
Loa	12/01/89	12/05/90	369	4	0.36	0.24	0.29	105
Logan	01/03/90	01/10/91	371	4	0.22	0.09	0.14	53
Lund	12/01/89	11/28/90	362	4	0.31	0.19	0.24	89
Milford	12/01/89	12/04/90	368	4	0.35	0.23	0.28	102
Monticello	11/07/89	10/31/90	358	4	0.26	0.17	0.20	74
Nephi	01/09/90	12/06/90	331	3	0.18	0.13	0.16	58
Parowan	12/01/89	12/04/90	368	4	0.20	0.12	0.16	58
Price	01/10/90	01/29/91	384	4	0.19	0.15	0.17	62
Provo	01/09/90	01/29/91	385	4	0.16	0.12	0.14	51
Salt Lake City	01/03/90	01/30/91	391	4	0.19	0.11	0.16	57
St. George	12/04/89	11/28/90	359	4	0.14	0.09	0.11	40
Trout Creek	11/29/89	12/05/90	370	4	0.23	0.13	0.18	64
Vernal	01/09/90	01/29/91	384	4	0.19	0.15	0.17	63
Vernon	01/08/90	01/30/91	387	4	0.26	0.16	0.20	72
Wendover	12/11/89	11/27/90	351	4	0.19	0.11	0.14	52
Willow Springs Lodge	01/09/90	01/30/91	385	4	0.17	0.13	0.15	53

[a] *Exposure at a fixed environmental TLD location in the monitoring period is calculated by multiplying the average (mean) exposure rate (mR/day) by the number of days included in this report. Exposure at the location in one year is calculated by multiplying the average (mean) mR/day by 365.25.*

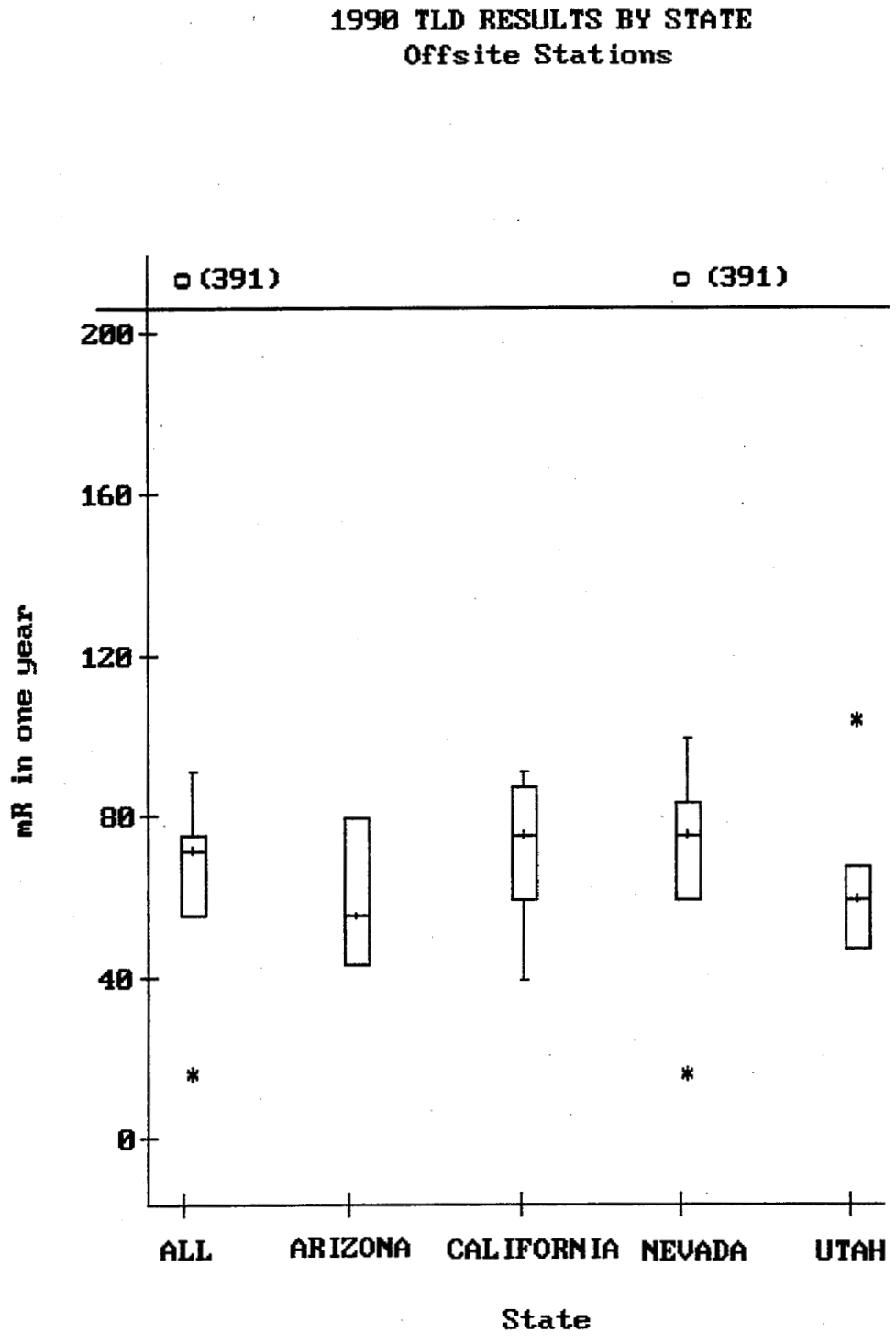


Figure A20. Thermoluminescent dosimeter monitoring results for fixed stations.

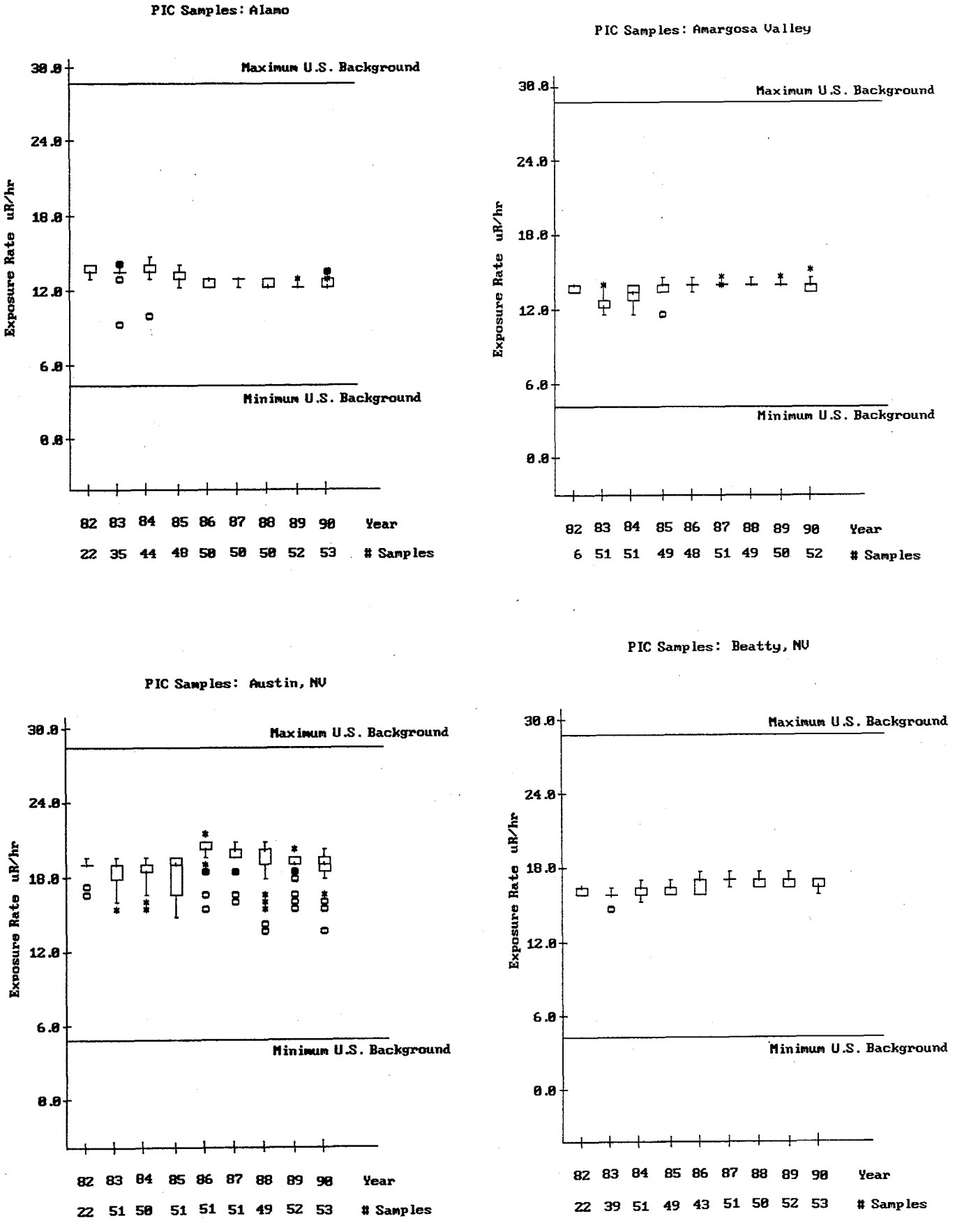
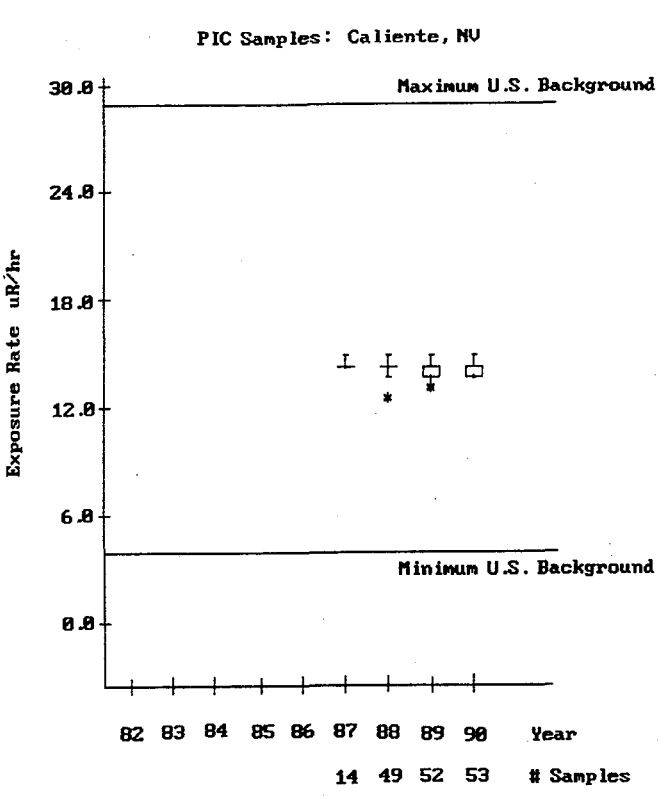
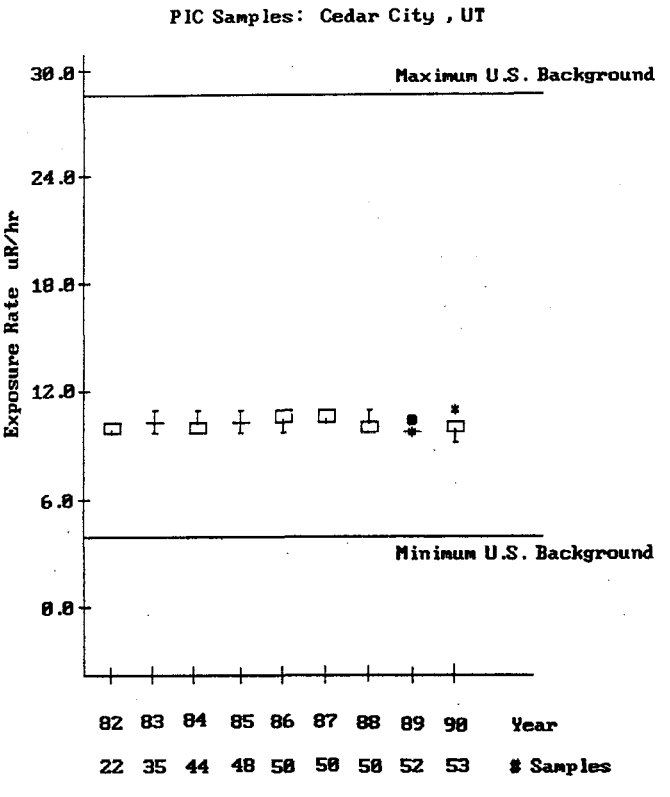
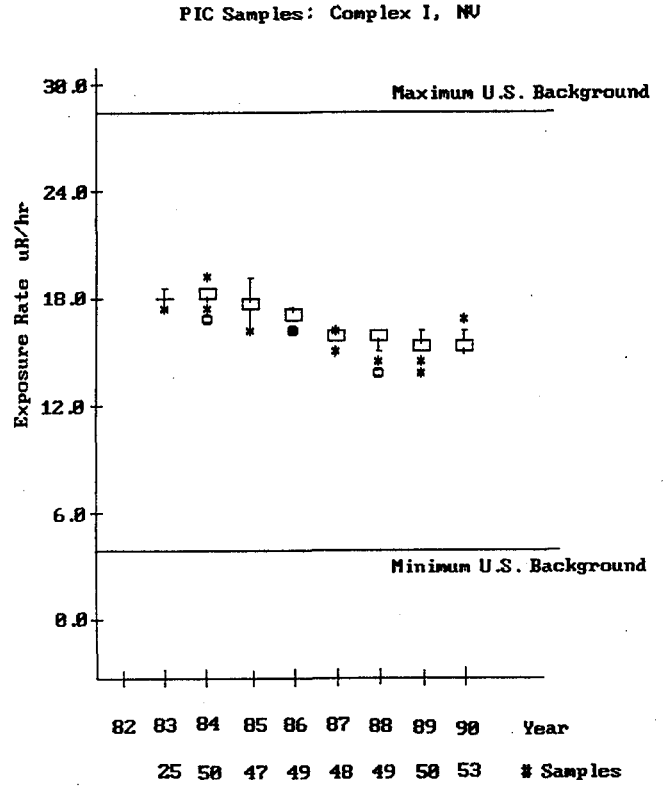


Figure A21. Historical trends of pressurized ion chamber samples by station.







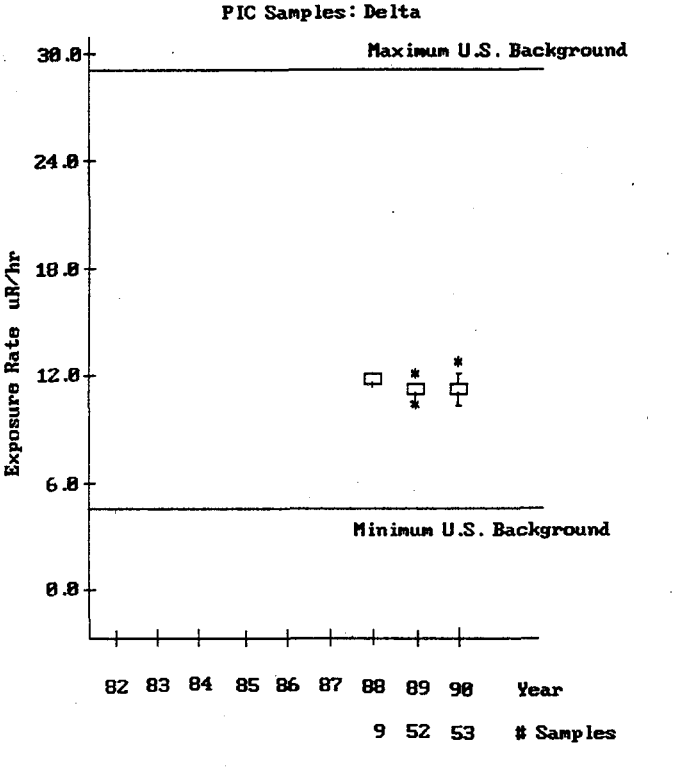
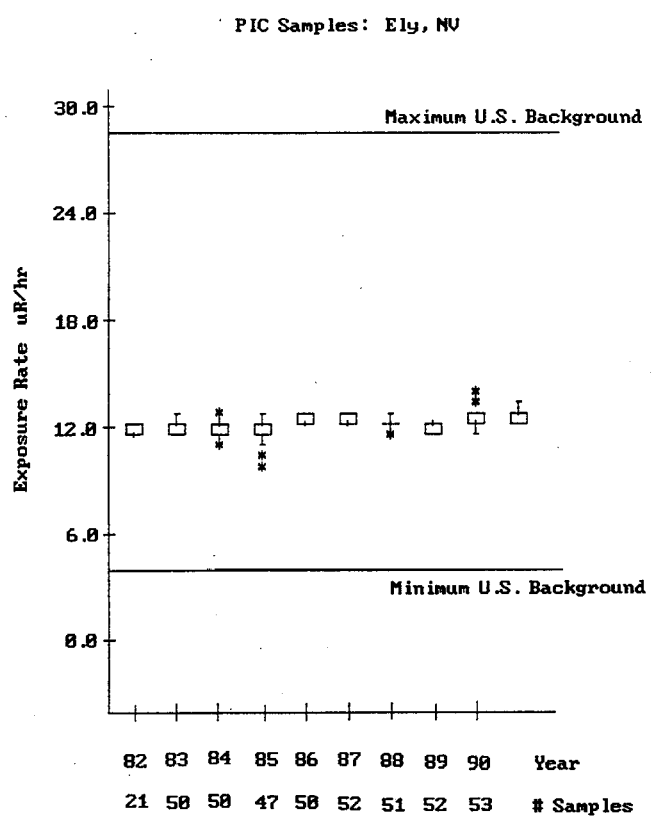
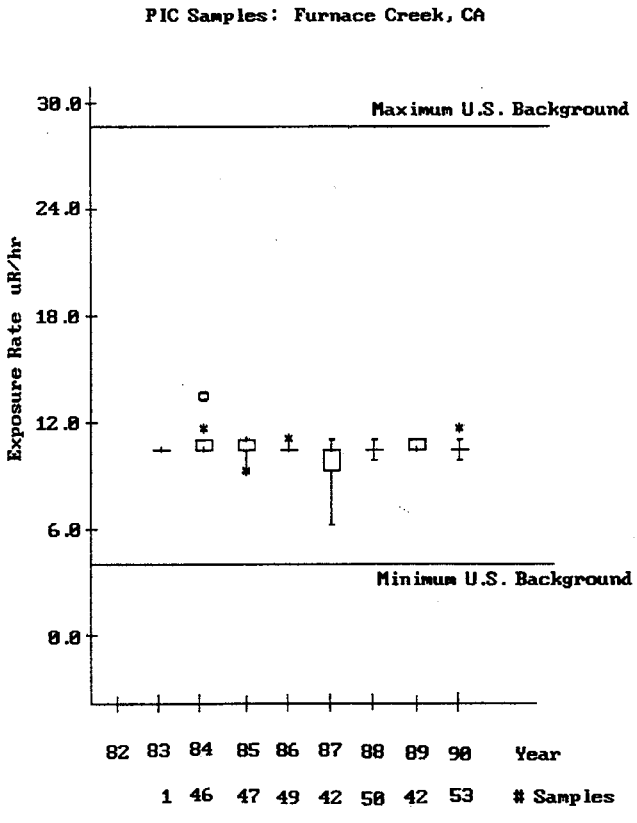
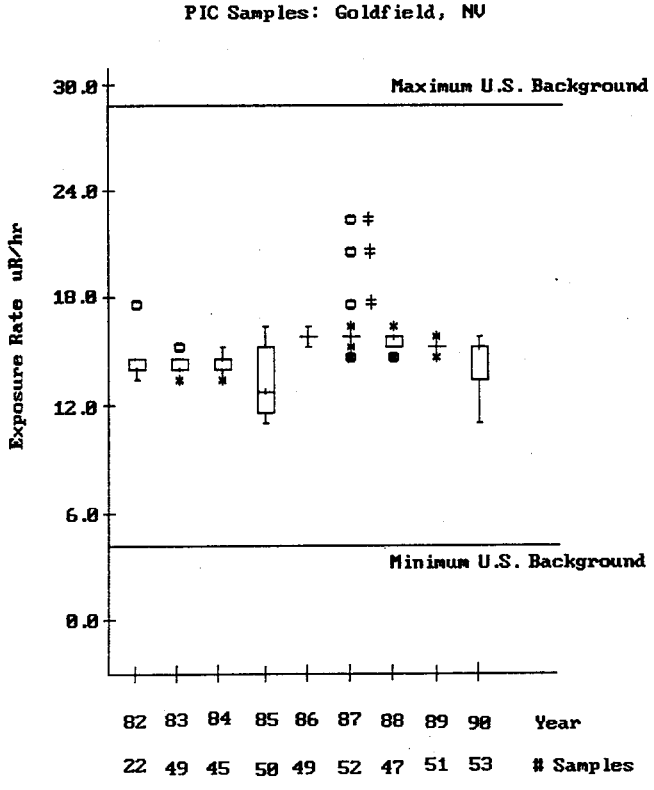
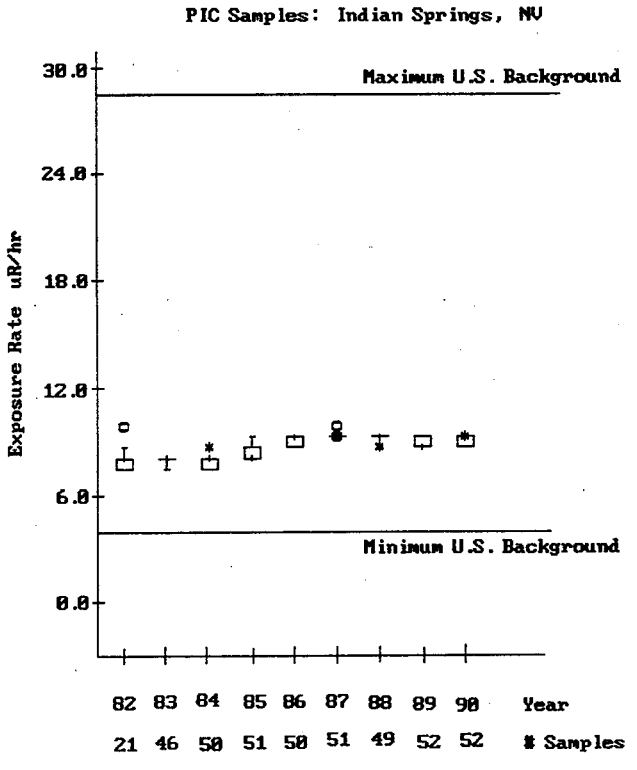


Figure A21. Continued.









‡ Electronics deteriorated gradually, PIC was replaced and values returned to normal.

Figure A21. Continued.

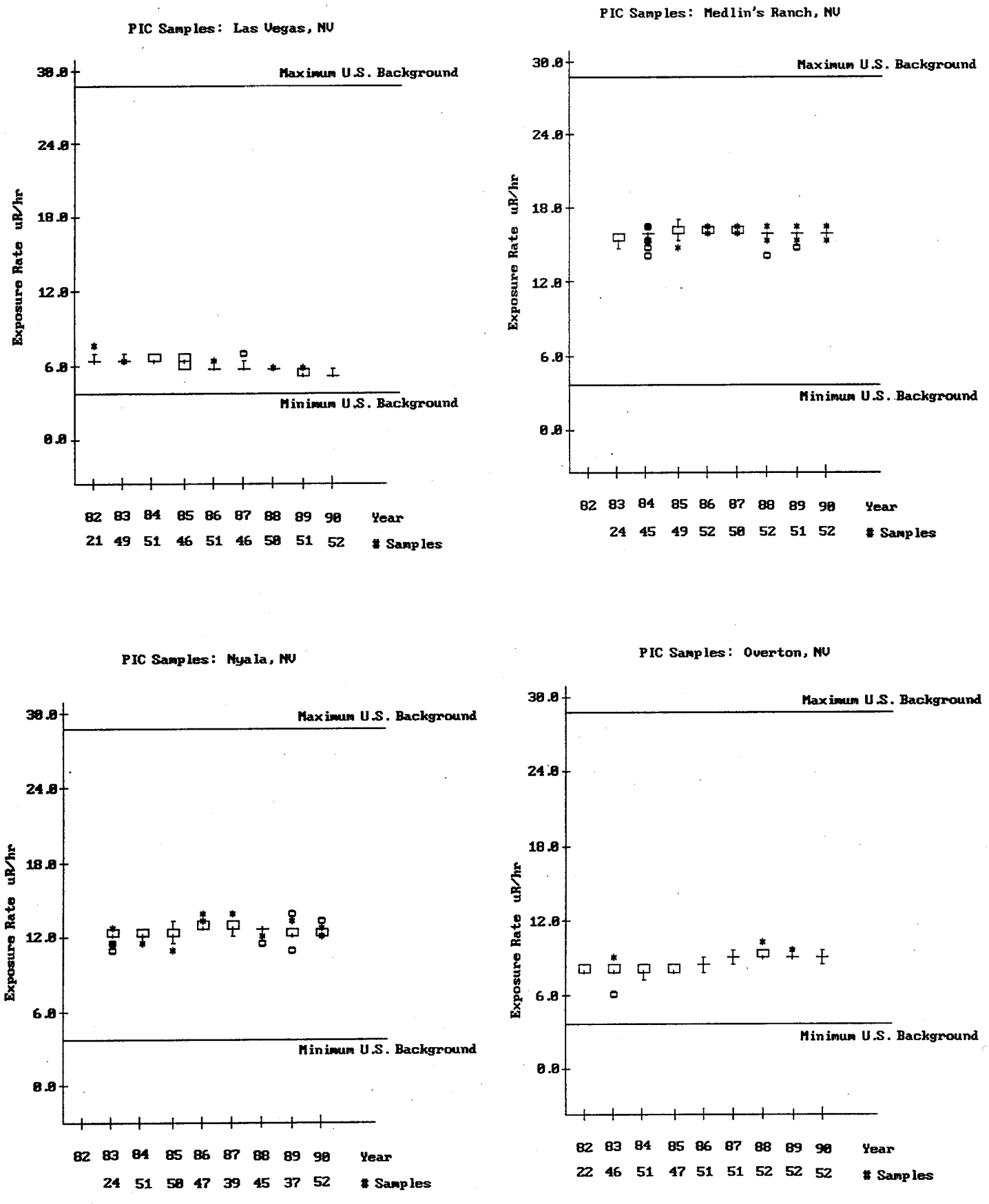
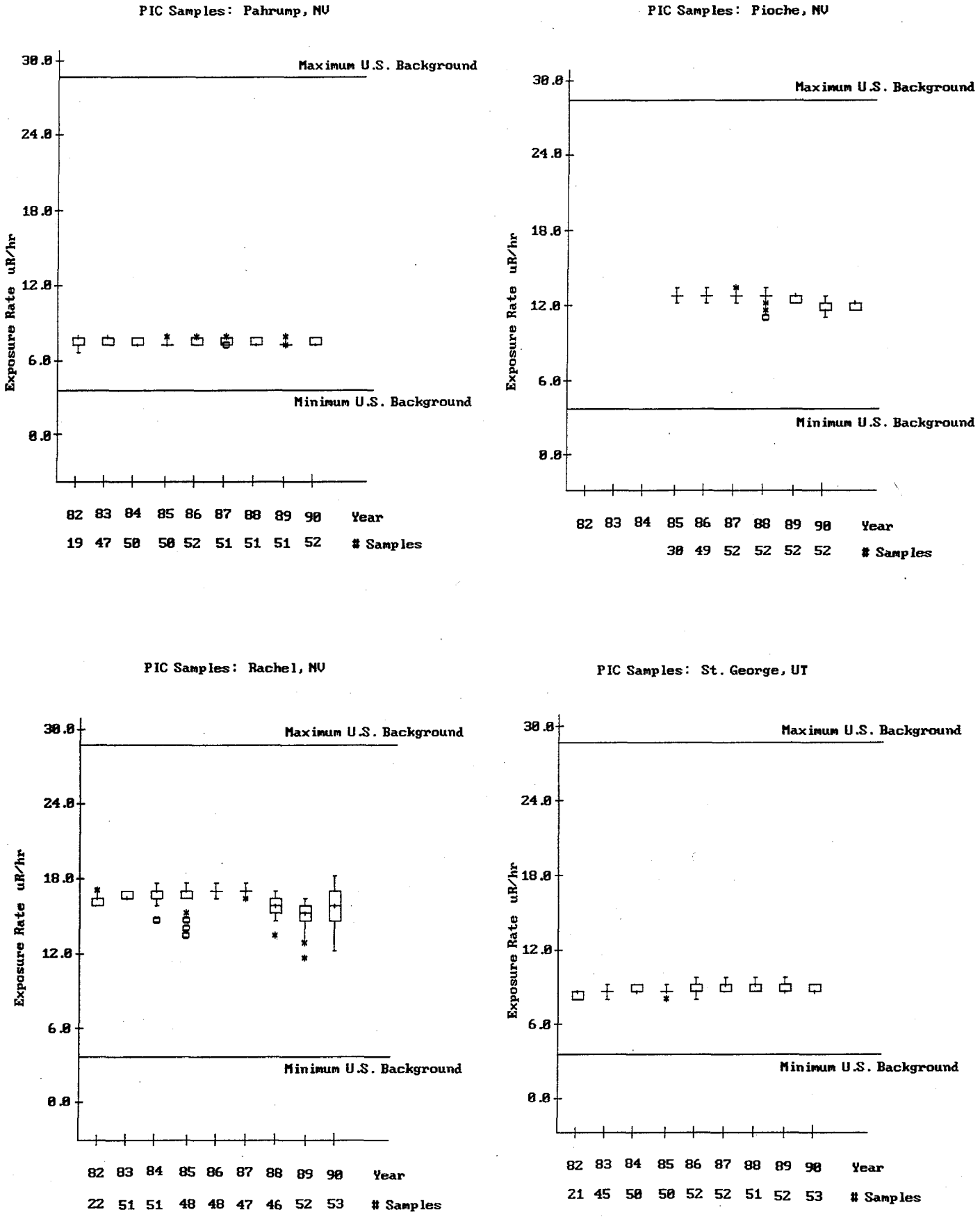


Figure A21. Continued.



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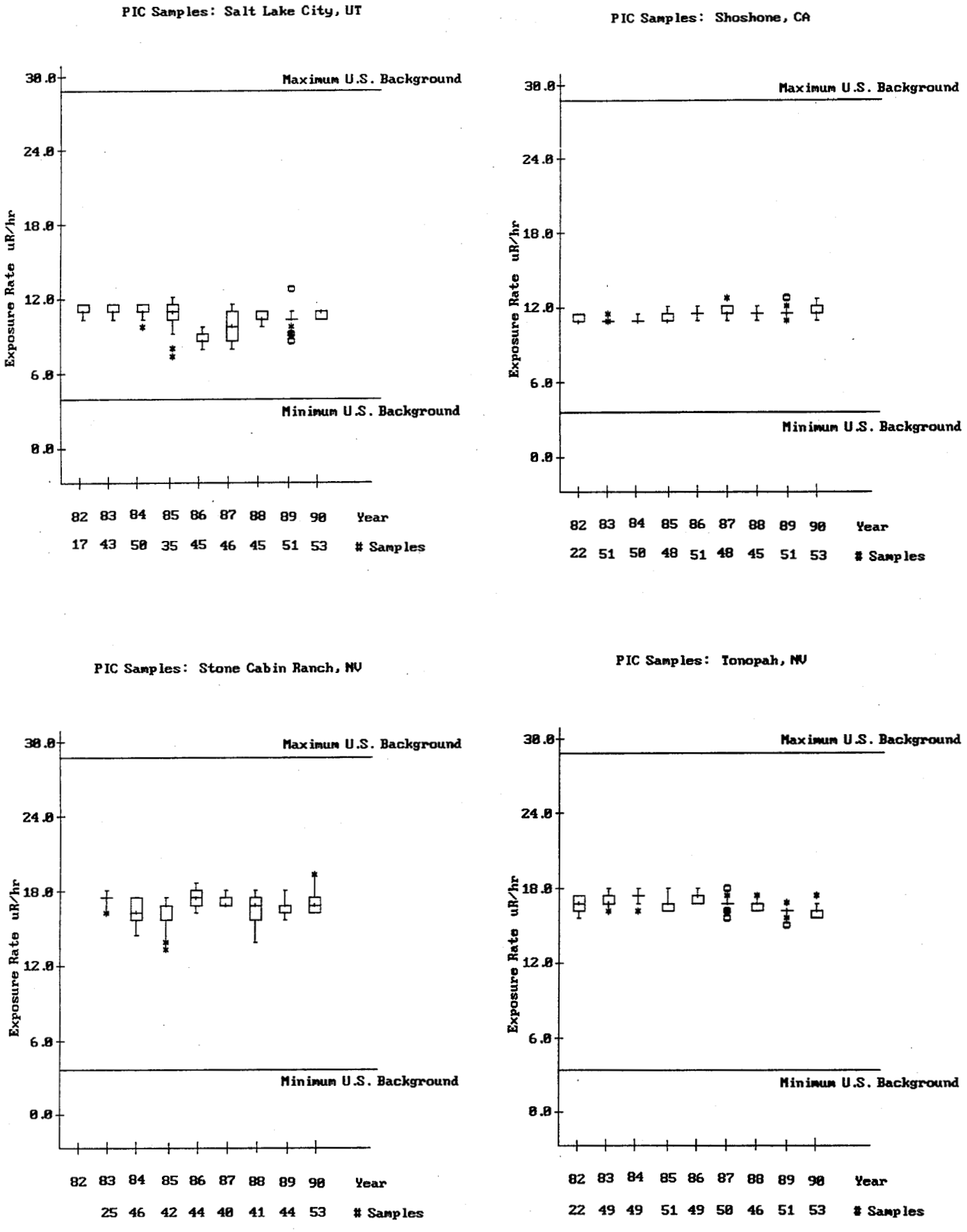

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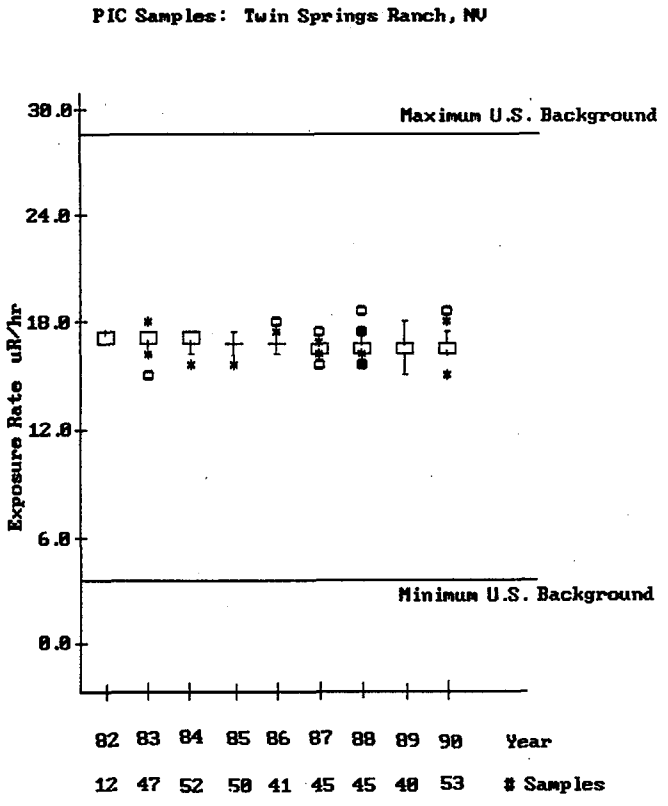


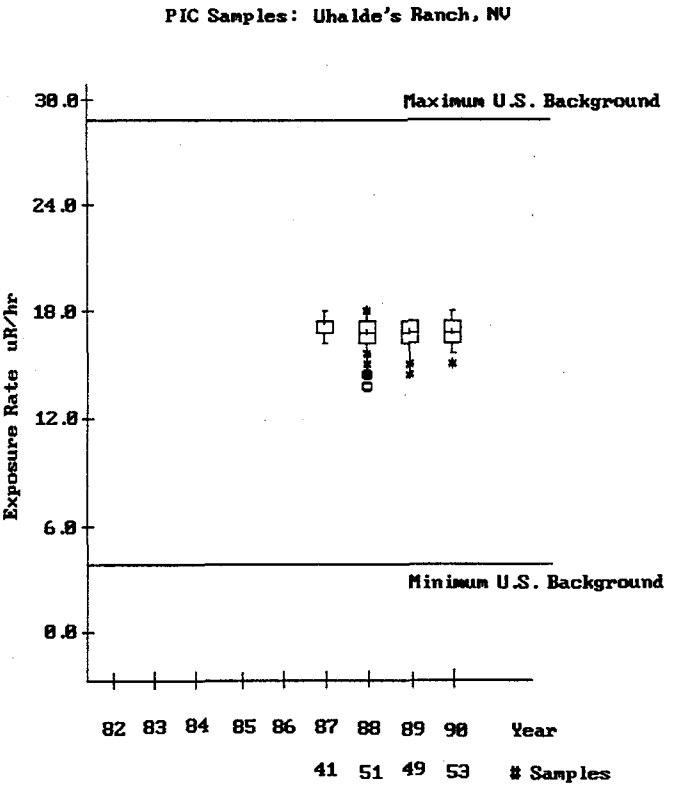


Figure A21. Continued.

TABLE A6. TRITIUM IN URINE, RADIOLOGICAL SAFETY PROGRAM — 1990

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S. D. (MDC) (10^{-9} µCi/mL)[a]	ORGANIZATION
LAS VEGAS NV	01/23	130 ± 95 (310)	EPA
	01/23	260 ± 92 (300)	EPA
	01/25	-2.0 ± 91 (300)	EPA
	02/15	1900 ± 100[b] (320)	EPA
	02/22	360 ± 99[b] (320)	Polish Scientist
	02/27	300 ± 97 (310)	Polish Scientist
	03/06	220 ± 96 (310)	EPA
	03/13	160 ± 93 (300)	EPA
	04/12	68 ± 95 (310)	EPA
	04/12	220 ± 100 (330)	EPA
	04/18	-170 ± 93 (310)	EPA
	04/18	-28 ± 94 (310)	EPA
	04/18	160 ± 98 (320)	EPA
	04/18	-61 ± 95 (310)	DOE
	04/19	25 ± 96 (320)	EPA
	04/19	-67 ± 110 (370)	DOE
	04/19	200 ± 98 (320)	EPA
	04/24	160 ± 110 (360)	EPA
	04/24	72 ± 100 (350)	EPA
	04/24	230 ± 100 (330)	EPA
	04/26	-2.3 ± 100 (350)	EPA
	04/26	11 ± 99 (330)	EPA
	04/26	97 ± 97 (320)	EPA
	04/27	1500 ± 100[b] (300)	SAIC
	05/17	6.2 ± 96 (310)	EPA
	05/18	-2.0 ± 93 (310)	EPA
	05/24	110 ± 94 (310)	EPA
	05/24	120 ± 98 (320)	EPA
	05/24	170 ± 97 (310)	EPA
	05/29	210 ± 95 (310)	EPA
	06/04	51 ± 95 (310)	EPA
	06/07	-49 ± 93 (310)	EPA
	06/07	-45 ± 94 (310)	EPA
	06/07	250 ± 97 (310)	EPA
	06/07	10 ± 95 (310)	EPA
	06/08	-23 ± 97 (320)	USGS
	06/08	-2.0 ± 94 (310)	USGS
	06/08	-68 ± 95 (310)	USGS
	06/08	-63 ± 93 (310)	USGS
	06/14	4.2 ± 98 (320)	EPA
	06/19	-49 ± 93 (310)	SAIC
	06/22	170 ± 97 (310)	EPA
	06/22	330 ± 100[b] (320)	EPA
	06/29	260 ± 96 (310)	EPA
	06/29	260 ± 99 (320)	EPA
	07/03	220 ± 74 (240)	EPA
	08/01	240 ± 73[b] (240)	EGG
	08/02	-20 ± 72 (240)	EPA
	08/09	54 ± 91 (300)	EPA
	10/02	18 ± 88 (290)	SAIC
	10/04	50 ± 87 (280)	LESC
	10/04	-52 ± 87 (290)	LESC
	10/04	-9.7 ± 87 (290)	LESC
	10/04	1000 ± 95[b] (290)	LESC
	10/09	88 ± 88 (290)	LESC
	10/10	-72 ± 87 (290)	LESC
	10/12	-65 ± 88 (290)	LESC
	10/14	-18 ± 87 (290)	LESC
	10/15	34 ± 89 (290)	LESC

(continued)

TABLE A6. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S. D. (MDC) (10^{-9} µCi/mL)[a]	ORGANIZATION
	10/15	400 ± 93[b] (300)	DRI
	10/16	53 ± 89 (290)	LESC
	10/31	14 ± 87 (290)	SAIC
	12/06	230 ± 110 (360)	SAIC
RENO NV			
	09/14	-46 ± 89 (290)	DRI
	11/28	73 ± 100 (350)	DRI
	12/17	-54 ± 100 (360)	DRI
	12/17	120 ± 110 (360)	DRI

[a]To convert to Bacquerals, multiply by 3.7 x 10^7 Bq/L.
[b]Concentration is greater than the minimum detectable concentration (MDC).
DOE = Department of Energy
DRI = Desert Research Institute
EPA = U.S. Environmental Protection Agency
LESC = Lockheed Engineering & Sciences Co., Inc.
USGS = U.S. Geological Survey

TABLE A7. TRITIUM IN URINE, OFFSITE INTERNAL DOSIMETRY PROGRAM — 1990

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S. D. (MDC) (10^{-9} μCi/mL)[a]	
SHOSHONE CA	06/21	270 ± 99	(320)
	06/21	140 ± 96	(310)
	06/21	180 ± 8	(280)
	06/21	93 ± 95	(310)
ALAMO NV	02/08	84 ± 93	(300)
	02/18	99 ± 93	(300)
BEATTY NV	01/26	10 ± 93	(310)
	01/31	130 ± 95	(310)
	01/31	160 ± 96	(310)
	02/14	120 ± 94	(310)
	02/14	80 ± 94	(310)
	02/23	67 ± 95	(310)
	02/23	-76 ± 95	(310)
	05/03	46 ± 90	(300)
	05/03	44 ± 90	(300)
	05/03	-4 ± 90	(300)
	05/03	-8 ± 91	(300)
	05/03	110 ± 92	(300)
	05/03	30 ± 91	(300)
	08/10	80 ± 71	(230)
	08/10	-84 ± 68	(230)
	08/31	130 ± 75	(240)
	08/07	42 ± 74	(240)
	08/07	20 ± 75	(250)
	08/07	140 ± 72	(250)
CALIENTE NV	07/23	49 ± 73	(240)
	07/23	110 ± 73	(240)
CURRANT NV			
BLUE EAGLE RANCH	03/14	370 ± 97[b]	(310)
	03/14	160 ± 92	(300)
	03/14	60 ± 91	(300)
ELY NV	04/27	230 ± 92	(300)
	04/27	75 ± 91	(300)
	07/16	13 ± 72	(240)
	07/16	94 ± 73	(240)
	12/12	200 ± 110	(360)
	12/12	140 ± 100	(350)
GOLDFIELD NV	05/16	210 ± 93	(300)
	05/16	260 ± 93	(300)
	05/16	-72 ± 94	(310)
	05/16	29 ± 94	(310)
INDIAN SPRINGS NV	04/10	62 ± 91	(300)
	04/10	190 ± 95	(310)
	07/10	150 ± 73	(240)
	07/10	160 ± 72	(230)
	07/10	120 ± 73	(240)
	12/17	82 ± 100	(350)
	12/17	78 ± 110	(360)
LAS VEGAS NV	01/24	60 ± 92	(300)
	01/24	140 ± 93	(300)
	02/08	270 ± 97	(310)

(continued)

TABLE A7. Continued

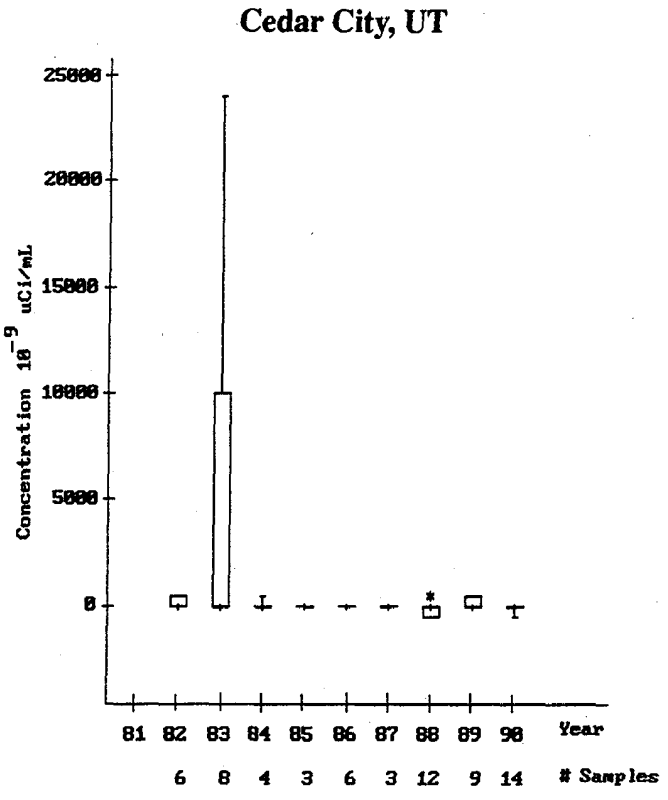
SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S. D. (MDC) (10^{-9} µCi/mL)[a]	
	03/07	160 ± 98	(320)
	03/07	-38 ± 97	(320)
AMAGOSA VALLEY NV	01/26	-18 ± 91	(300)
AMARGOSA CENTER NV	01/10	66 ± 92	(300)
	08/06	120 ± 73	(240)
	08/06	-32 ± 72	(240)
	08/14	-45 ± 74	(240)
	08/14	14 ± 72	(240)
LUND NV	01/26	-12 ± 92	(300)
	01/26	80 ± 92	(300)
MCGILL NV	01/08	89 ± 93	(310)
	01/08	8 ± 91	(300)
NYALA NV	06/14	-120 ± 100	(340)
	06/14	47 ± 100	(330)
	06/14	-13 ± 98	(320)
	12/10	-69 ± 100	(360)
OVERTON NV	04/10	310 ± 93[b]	(300)
	04/10	22 ± 91	(300)
	04/10	-64 ± 90	(300)
	04/10	-49 ± 91	(300)
	04/10	51 ± 91	(300)
	04/10	170 ± 92	(300)
	05/04	300 ± 93[b]	(300)
	05/04	100 ± 92	(300)
	05/04	100 ± 91	(300)
	05/04	550 ± 97[b]	(310)
	05/04	83 ± 91	(300)
PAHRUMP NV	03/07	180 ± 92	(300)
	06/19	300 ± 100	(320)
	06/19	220 ± 98	(320)
	06/25	160 ± 99	(320)
	06/25	360 ± 99[b]	(320)
PIOCHE NV	02/20	150 ± 98	(320)
	02/20	180 ± 95	(310)
	02/20	210 ± 95	(310)
	02/20	10 ± 93	(310)
	02/20	29 ± 96	(320)
	08/09	170 ± 73	(240)
	08/09	-66 ± 71	(240)
	08/09	40 ± 72	(240)
	08/09	83 ± 72	(230)
	08/09	-130 ± 70	(240)
RACHEL NV	03/02	150 ± 97	(320)
	03/02	88 ± 95	(310)
	03/02	-57 ± 94	(310)
	03/02	-65 ± 96	(320)
	03/02	-89 ± 95	(310)
	06/01	4 ± 94	(310)

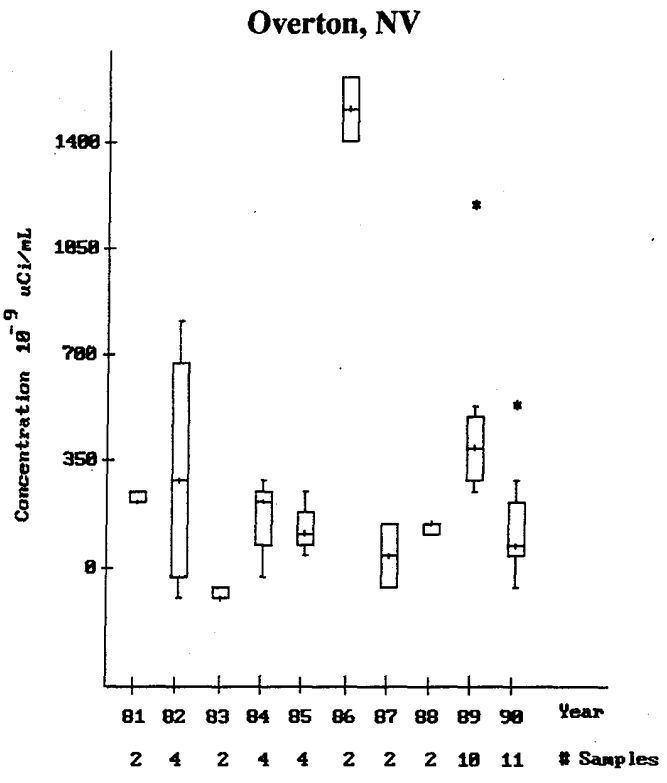
(continued)

TABLE A7. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S. D. (MDC) (10^{-9} µCi/mL)[a]
WARM SPRINGS NV		
HOT CREEK VALLEY	12/10	28 ± 100 (350)
CEDAR CITY UT	02/16	170 ± 95 (310)
	02/16	200 ± 95 (310)
	02/16	120 ± 9 (300)
	02/16	10 ± 93 (310)
	02/16	21 ± 94 (310)
	06/08	97 ± 99 (320)
	06/18	-130 ± 98 (330)
	06/19	17 ± 99 (330)
	11/30	120 ± 100 (330)
	11/30	61 ± 100 (360)
	11/30	170 ± 110 (360)
	11/30	110 ± 110 (350)
	11/30	170 ± 110 (360)
	11/30	150 ± 110 (360)
MILFORD UT	02/09	130 ± 93 (300)
	02/09	59 ± 93 (310)

[a]To convert to Bacquerals, multiply by 3.7 x 10^7 Bq/L.
[b]Concentration is greater than the minimum detectable concentration (MDC).





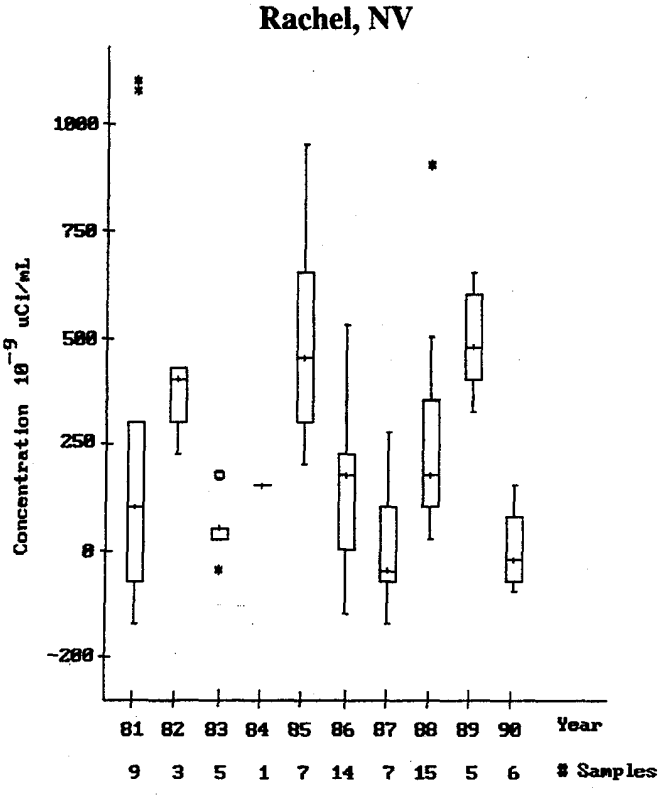


Figure A22. Historical trends of ^{3}H in urine samples.

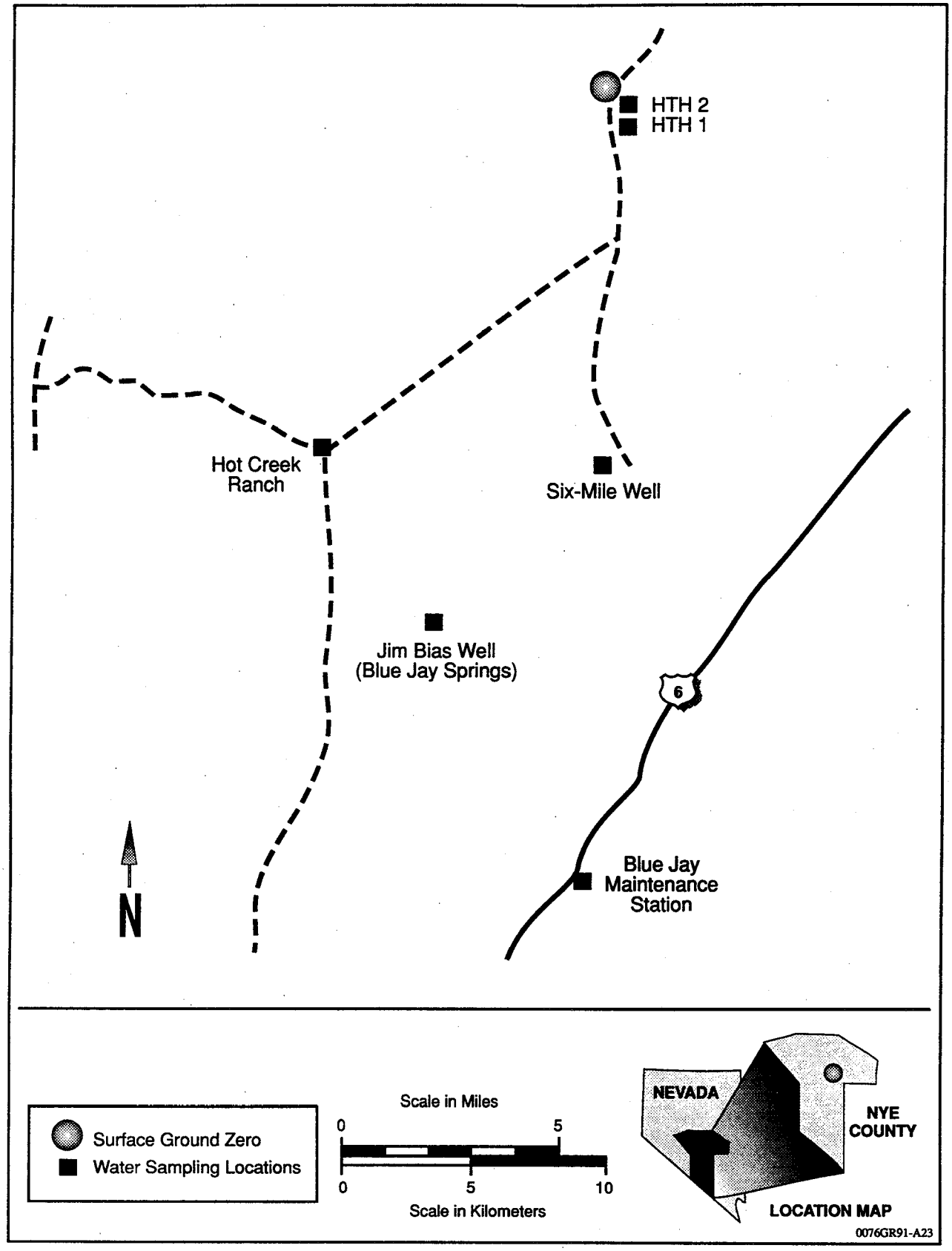


Figure A23. Long-Term Hydrological Monitoring Program sampling locations for Project Faultless.

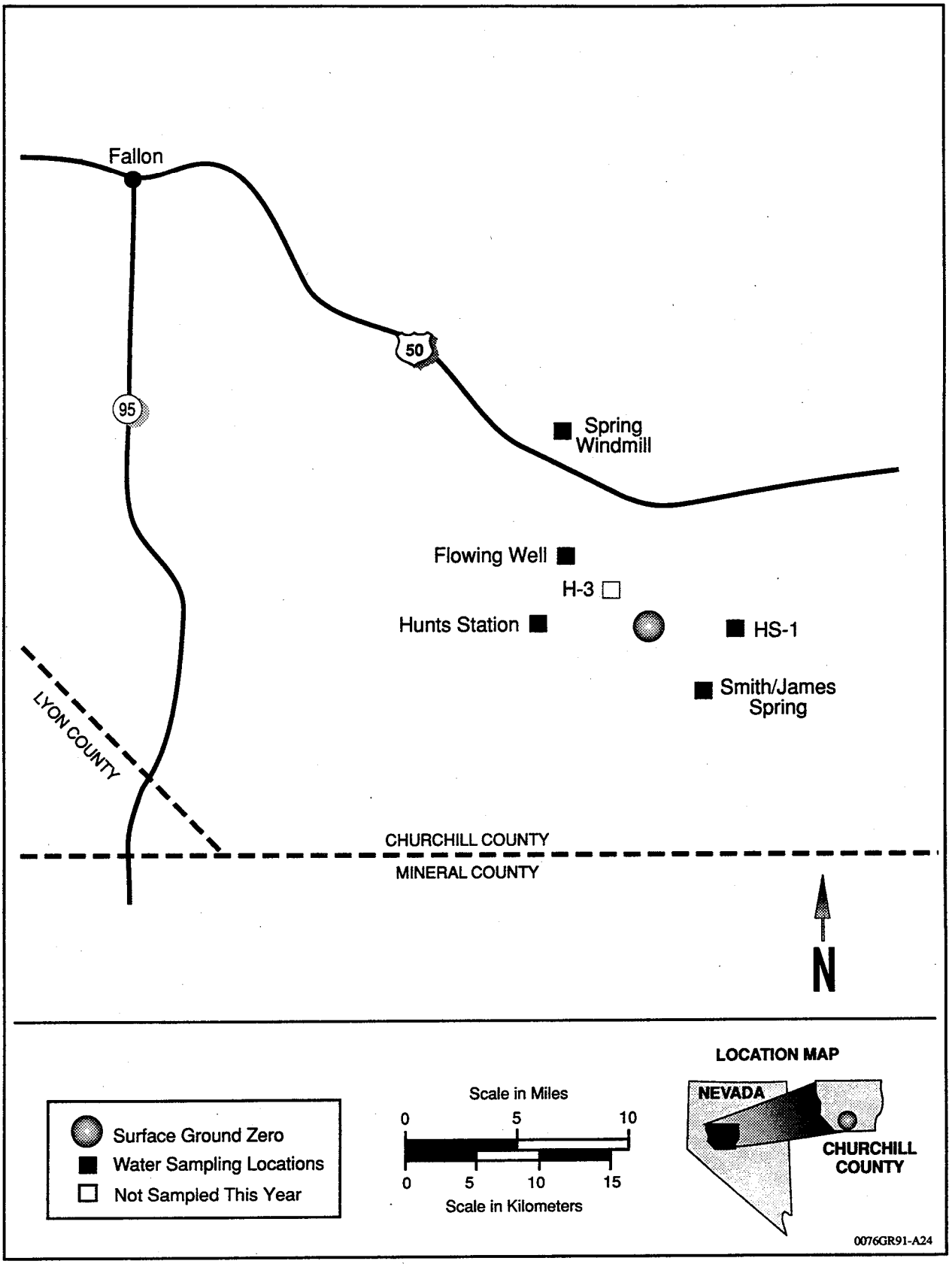


Figure A24. Long-Term Hydrological Monitoring Program sampling locations for Project Shoal.

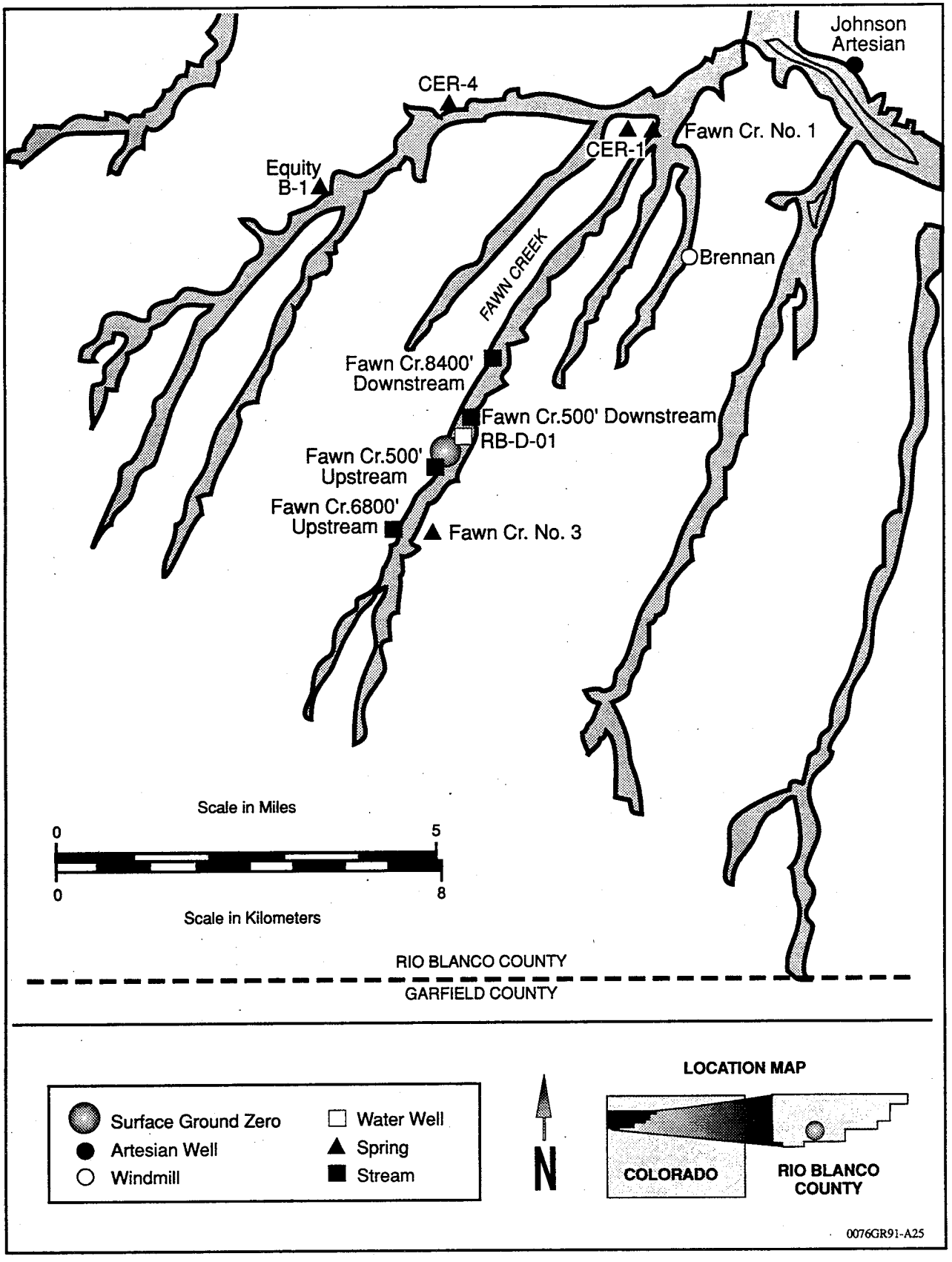


Figure A25. Long-Term Hydrological Monitoring Program sampling locations for Project Rio Blanco.

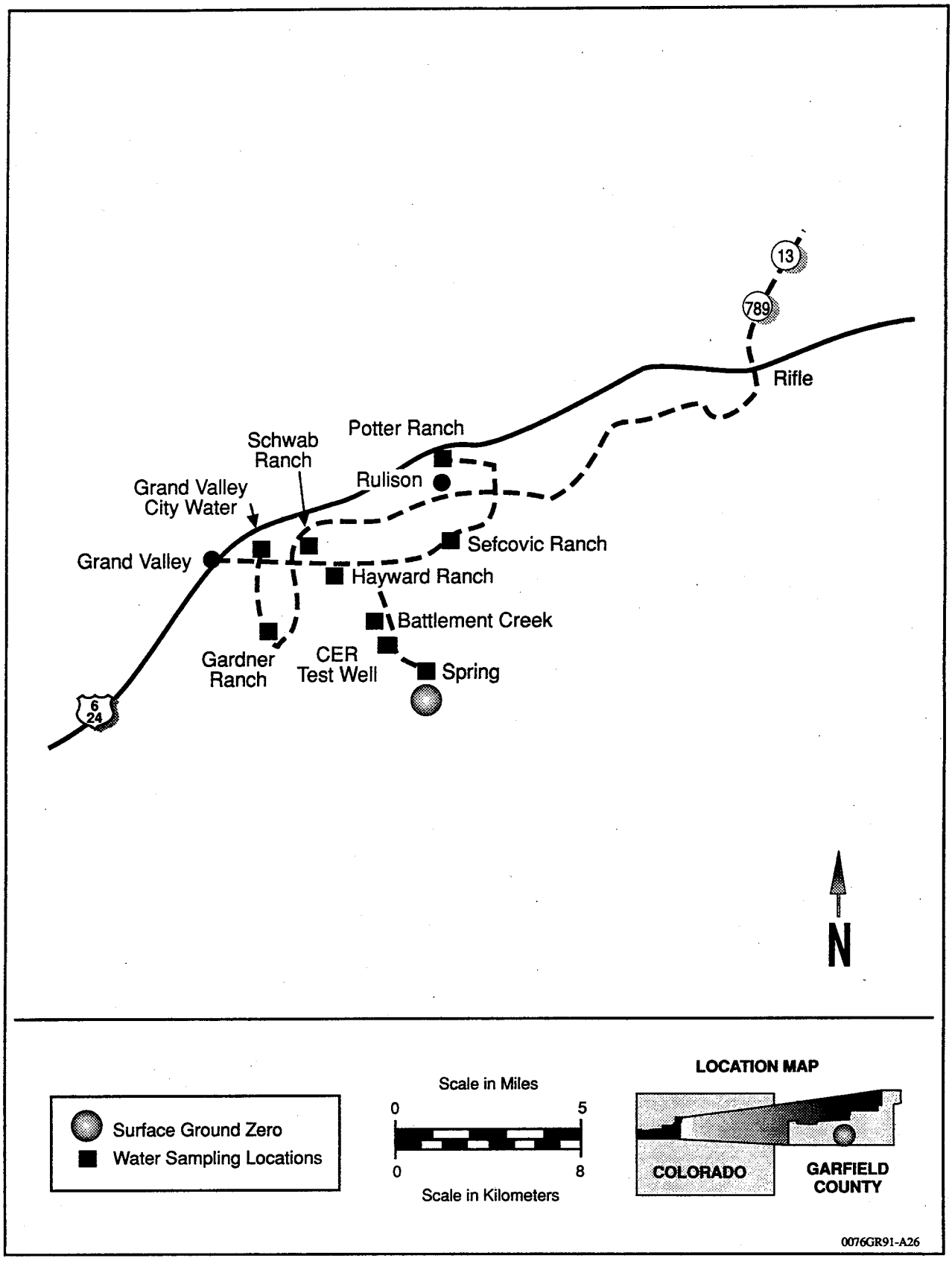


Figure A26. Long-Term Hydrological Monitoring Program sampling locations for Project Rulison.

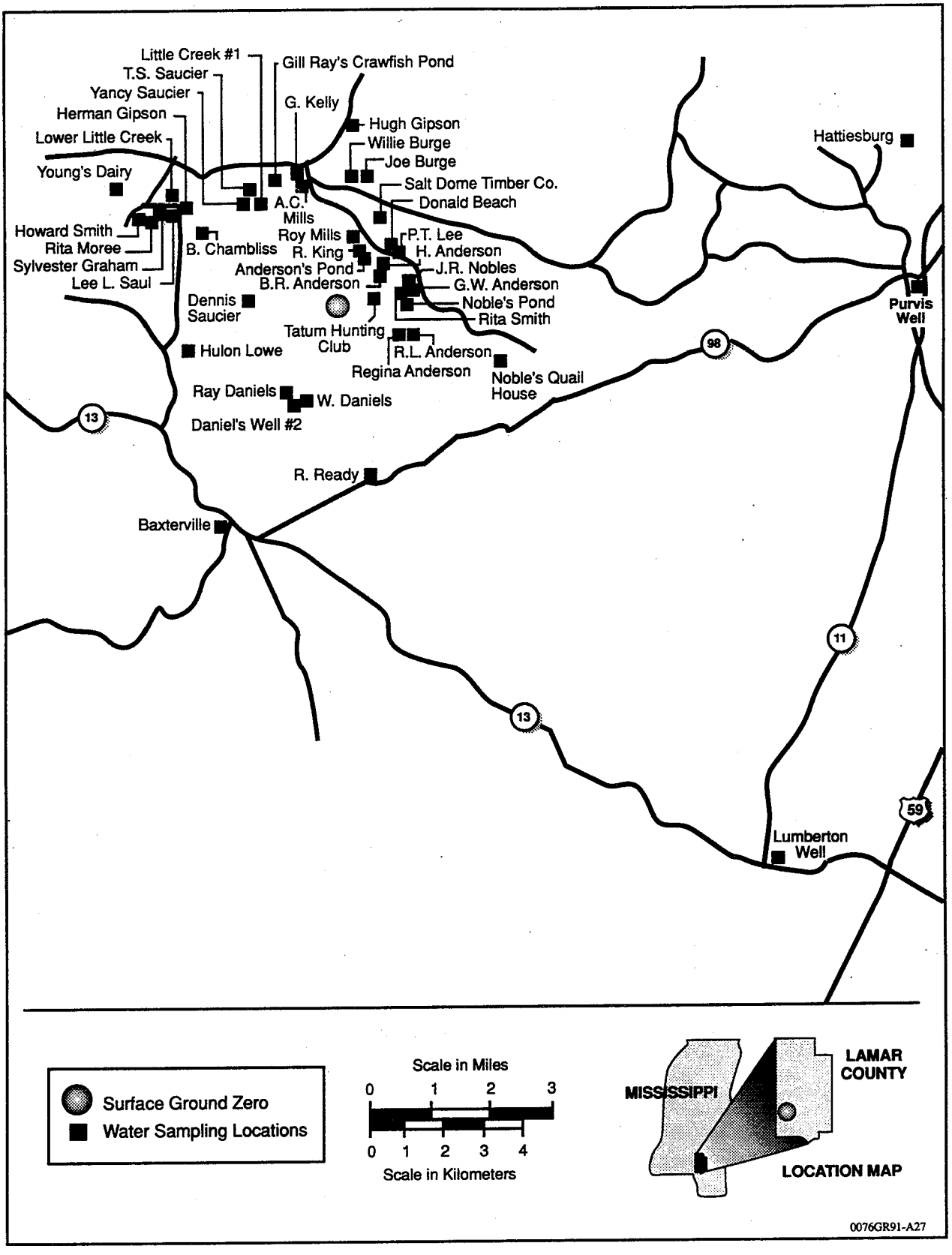


Figure A27. Long-Term Hydrological Monitoring Program sampling locations for Project Dribble — towns and residences.

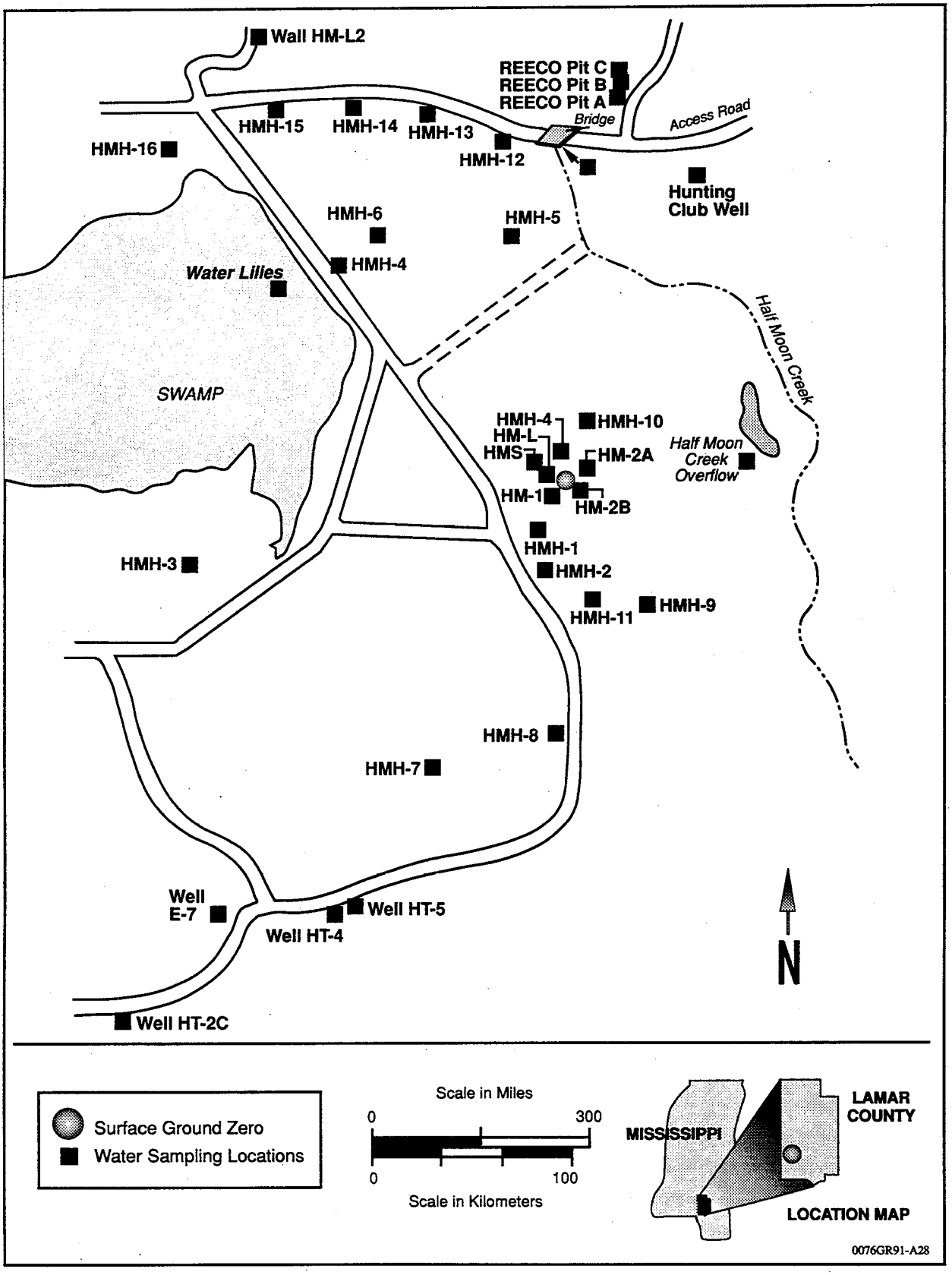


Figure A28. Long-Term Hydrological Monitoring Program sampling locations for Project Dribble — near ground zero.

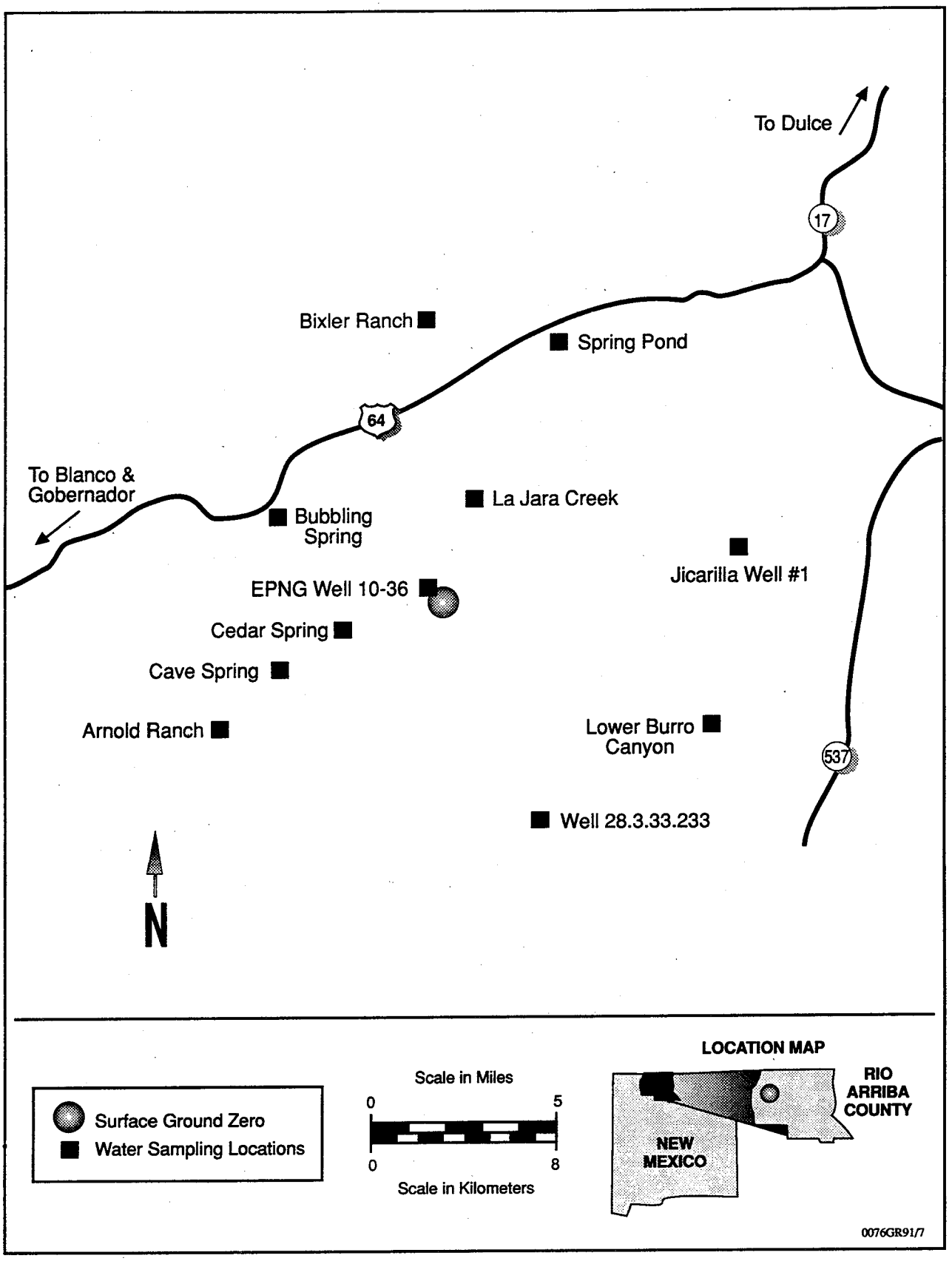


Figure A29. Long-Term Hydrological Monitoring Program sampling locations for Project Gasbuggy.

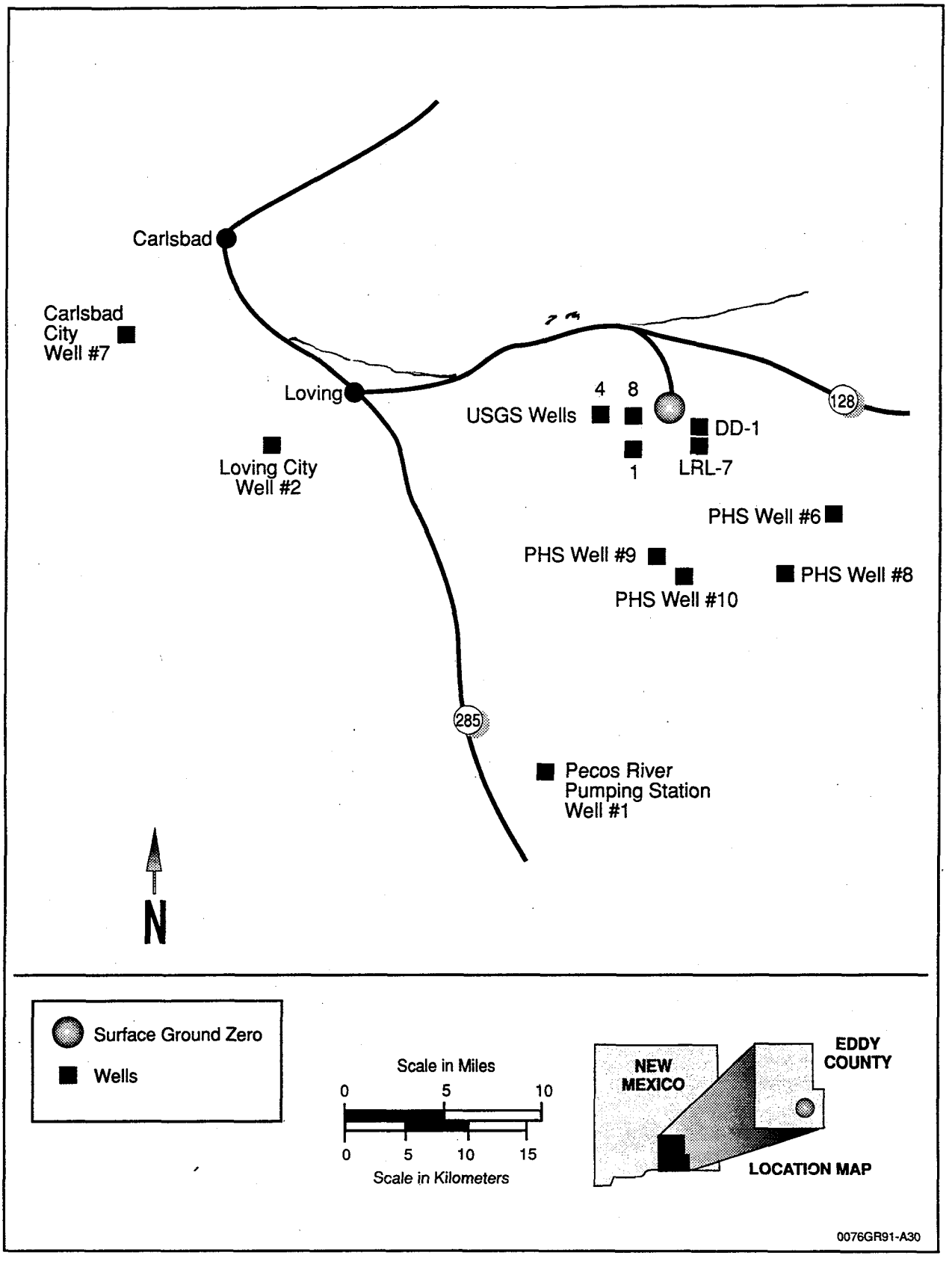


Figure A30. Long-Term Hydrological Monitoring Program sampling locations for Project Gnome.

TABLE A8. TRITIUM RESULTS FOR THE LONG-TERM HYDROLOGICAL MONITORING PROGRAM — 1990

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S.D. pCi/L (10^{-9} μCi/mL)[a]	% OF CONC. GUIDE	
	PROJECT GNOME			
CARLSBAD NM				
WELL 7 CITY	08/01	2.9 ± 3.0[b]	0.01	
LOVING NM				
WELL 2 CITY	08/01	8.1 ± 3.4[b]	0.04	
MALAGA NM				
WELL 1 PECOS PUMPING STATION	08/01	7 ± 3.7[b]	0.03	
WELL DD-1	08/02	28000000 ± 100000	140000	(3)
WELL LRL-7	08/02	14000 ± 190	71.4	(1)
WELL PHS 8	08/01	27 ± 4.5	0.13	
WELL PHS 9	08/02	13 ± 4.2[b]	0.07	
WELL PHS 10	08/03	4.6 ± 4.0[b]	0.02	
WELL USGS 1	08/01	-1.6 ± 2.2[b]	<0.01	
WELL USGS 4	08/02	150000 ± 490	767	
WELL USGS 8	08/02	120000 ± 440	603	(2)
	PROJECT DRIBBLE			
BAXTERVILLE MS				
HALF MOON CREEK	04/21	300 ± 4.5	1.54	
	04/23	19 ± 3.4	0.09	
HALF MOON CREEK OVRFLW	04/21	450 ± 4.3	2.27	
	04/23	390 ± 5.1	1.97	
LITTLE CREEK #1	04/20	7.1 ± 3.7[b]	0.04	
LOWER LITTLE CREEK	04/18	680 ± 140	3.38	
	04/18	14 ± 3.3	0.07	
POND WEST OF GZ	04/21	2.3 ± 2.2[b]	0.01	
	04/23	25 ± 3.2	0.13	
REECO PIT DRAINAGE-A	04/23	21 ± 3.0	0.10	
REECO PIT DRAINAGE-B	04/23	130 ± 3.3	0.69	
REECO PIT DRAINAGE-C	04/23	150 ± 4.7	0.79	
SALT DOME HUNTING CLUB	04/21	6.9 ± 2.5[b]	0.03	
SALT DOME TIMBER CO.	04/18	19 ± 3.7	0.09	
ANDERSON POND	04/21	5.4 ± 3.0[b]	0.03	
ANDERSON, BILLY RAY	04/21	11 ± 3.3	0.06	
ANDERSON, REGINA	04/20	7.9 ± 3.6[b]	0.04	
ANDERSON, ROBERT HARVEY	04/21	17 ± 2.9	0.08	
ANDERSON, ROBERT LOWELL	04/20	12 ± 3.7	0.06	
BURGE, JOE	04/21	6.3 ± 5.1[b]	0.03	
CHAMBLISS, B.	04/19	3.1 ± 5.6[b]	0.02	
DANIELS, RAY	04/18	20 ± 3.6	0.10	
DANIELS, WEBSTER JR.	04/18	31 ± 2.8	0.15	
DANIELS - WELL #2	04/18	25 ± 2.9	0.13	
KELLY GERTRUDE	04/19	-1.4 ± 3.8[b]	<0.01	
KING, RHONDA	04/21	13 ± 2.2	0.07	
LEE, P. T.	04/19	23 ± 3.6	0.11	
MILLS, A. C.	04/19	0 ± 4.5[b]	<0.01	
MILLS, ROY	04/19	29 ± 5.0	0.15	
NOBLES POND	04/19	21 ± 3.1	0.10	
NOBLES QUAIL HOUSE	04/21	44 ± 3.4	0.22	
NOBLE, W. H., JR.	04/19	30 ± 2.6	0.15	
READY, R C	04/18	12 ± 2.7	0.06	
SAUCIER, DENNIS	04/18	18 ± 3.2	0.09	

(continued)

TABLE A8. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S.D. pCi/L (10^{-9} µCi/mL)[a]	% OF CONC. GUIDE
BAXTERVILLE MS (con't)			
SAUCIER, TALMADGE S.	04/20	10 ± 3.5[b]	0.05
SAUCIER, WILMA & YANCY	04/20	20 ± 2.8	0.10
SMITH, RITA	04/19	-0.50 ± 3.6[b]	<0.01
WELL CITY	04/17	13 ± 3.4	0.07
WELL E-7	04/21	7.4 ± 2.7[b]	0.04
WELL HM-1	04/21	0.11 ± 3.5[b]	<0.01
	04/21	3.6 ± 3.6[b]	0.02
	04/21	2.0 ± 3.3[b]	0.01
	04/21	5.1 ± 3.3[b]	0.03
WELL HM-2A	04/21	6.5 ± 3.4[b]	0.03
	04/21	0.32 ± 2.6[b]	<0.01
WELL HM-2B	04/21	6.7 ± 3.6[b]	0.03
	04/21	0.52 ± 3.4[b]	<0.01
WELL HM-3	04/21	3.5 ± 3.3[b]	0.02
	04/21	4.2 ± 3.0[b]	0.02
WELL HM-L	04/21	910 ± 150	4.56
	04/21	1300 ± 150	6.51
	04/21	1000 ± 140	5.45
	04/21	940 ± 150	4.71
WELL HM-L2	04/21	4.4 ± 3.4[b]	0.02
	04/21	-7.9 ± 3.6[b]	<0.01
WELL HM-S	04/21	9300 ± 180	46.5
	04/21	9500 ± 180	47.7
WELL HMH-1	04/21	4000 ± 160	19.8
WELL HMH-2	04/21	8100 ± 180	41.0
WELL HMH-3	04/21	22 ± 3.0	0.11
WELL HMH-4	04/21	14 ± 2.8	0.07
WELL HMH-5	04/21	1800 ± 150	9.41
WELL HMH-6	04/21	110 ± 3.3	0.59
WELL HMH-8	04/21	25 ± 3.2	0.13
WELL HMH-9	04/21	92 ± 3.1	0.46
WELL HMH-10	04/21	19 ± 3.4	0.09
WELL HMH-11	04/21	36 ± 3.6	0.18
WELL HMH-12	04/21	8.0 ± 2.9[b]	0.04
	04/19	1.4 ± 4.0[b]	<0.01
	04/21	4.3 ± 4.0[b]	0.02
WELL HMH-13	04/21	51 ± 3.2	0.25
	04/19	5.6 ± 3.5[b]	0.03
	04/21	-0.85 ± 3.1[b]	<0.01
WELL HMH-14	04/21	18 ± 3.0	0.09
	04/19	1.2 ± 4.6[b]	<0.01
	04/21	10 ± 3.9[b]	0.05
WELL HMH-15	04/21	9.7 ± 4.5[b]	0.05
	04/19	0.0 ± 3.7[b]	<0.01
	04/21	2.3 ± 3.7[b]	0.01
WELL HMH-16	04/21	550 ± 4.5	2.76
	04/19	970 ± 140	4.85
	04/21	490 ± 5.3	2.49
WELL HT-2C	04/22	6.8 ± 3.0[b]	0.03
WELL HT-4	04/22	0.67 ± 3.0[b]	<0.01
WELL HT-5	04/22	0.17 ± 3.1[b]	<0.01
COLUMBIA MS			
WELL 64B CITY	04/17	12 ± 3.4	0.06

(continued)

TABLE A8. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S.D. pCi/L (10^{-9} μCi/mL)[a]	% OF CONC. GUIDE	
LUMBERTON MS				
ANDERSON, G W	04/20	27 ± 3.6	0.13	
GIL RAY'S CRAWFISH POND	04/23	13 ± 3.2	0.07	
GIPSON, HERMAN	04/19	12 ± 3.8	0.06	
GRAHAM, SYLVESTER	04/23	-1.3 ± 3.0[b]	<0.01	
MOREE, RITA - HOUSE WELL	04/20	-4.0 ± 3.2[b]	<0.01	
BEACH, DONALD	04/23	21 ± 4.6	0.10	
SAUL, LEE L	04/23	-1.4 ± 3.1[b]	<0.01	
SMITH, HOWARD	04/20	-2.9 ± 3.7[b]	<0.01	
WELL 2 CITY	04/17	3.4 ± 1.7[b]	0.02	
PURVIS MS				
CITY SUPPLY	04/17	-0.78 ± 3.5[b]	<0.01	
	PROJECT GASBUGGY			
GOBERNADOR NM				
ARNOLD RANCH	06/22	0.0 ± 2.3[b]	<0.01	
BIXLER RANCH	06/22	10 ± 2.7	0.05	
BUBBLING SPRINGS	06/22	13 ± 2.6	0.07	
CAVE SPRINGS	06/21	53 ± 2.7	0.26	
CEDAR SPRINGS	06/21	23 ± 2.7	0.11	
LA JARA CREEK	06/21	2.4 ± 2.2[b]	0.01	
LOWER BURROW CANYON	06/24	63 ± 3.2	0.32	
POND N WELL 30.3.32.343	06/22	41 ± 2.8	0.21	
WELL EPNG 10-36	06/24	230 ± 4.5	1.16	
WELL JICARILLA 1	06/21	9.0 ± 2.4	0.05	
WELL 28.3.33.233 (SOUTH)	06/24	59 ± 3.5	0.29	(4)
	PROJECT RULISON			
GRAND VALLEY CO				
BATTLEMENT CREEK	06/19	22 ± 2.2	0.11	
CITY SPRINGS	06/19	9.9 ± 4.1[b]	0.05	
ALBERT GARDNER RANCH	06/19	87 ± 5.0	0.43	
SPRING 300 YRD N OF GZ	06/19	18 ± 2.0	0.09	
WELL CER TEST	06/19	41 ± 2.2	0.21	
RULISON CO				
LEE HAYWARD RANCH	06/19	88 ± 2.7	0.44	
POTTER RANCH	06/19	43 ± 2.1	0.22	
ROBERT SEARCY RN (SCHWAB)	06/19	41 ± 2.8	0.21	
FELIX SEFCOVIC RANCH	06/19	27 ± 2.6	0.13	
	PROJECT RIO BLANCO			
RIO BLANCO CO				
BRENNAN WINDMILL	06/17	6.6 ± 2.5[b]	0.03	
CER NO.1 BLACK SULPHUR	06/18	340 ± 6.0	1.73	
CER NO.4 BLACK SULPHUR	06/18	56 ± 4.8	0.28	
FAWN CREEK 3	06/17	22 ± 2.5	0.11	
FAWN CREEK 3 (DUPLICATE)	06/17	24 ± 2.5	0.12	
FAWN CREEK 500FT UPSTRM	06/17	34 ± 2.7	0.17	
FAWN CREEK 500FT DWNSTRM	06/17	33 ± 2.7	0.17	
FAWN CREEK 6800FT UPSTRM	06/17	31 ± 2.5	0.15	
FAWN CREEK 8400FT DWNSTR	06/12	29 ± 2.7	0.15	

(continued)

TABLE A8. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S.D. pCi/L (10^{-9} μCi/mL)[a]	% OF CONC. GUIDE
RIO BLANCO CO (con't)			
WELL JOHNSON ARTESIAN	06/17	0.99 ± 2.7[b]	<0.01
WELL RB-D-01	06/18	3.3 ± 3.8[b]	0.02
WELL RB-D-03	06/17	0.65 ± 2.8[b]	<0.01
WELL RB-S-03	06/18	4.1 ± 4.3[b]	0.02
B-1 EQUITY CAMP	06/18	71 ± 5.5	0.36
	NTS SEMIANNUAL NETWORK		
HIKO NV			
CRYSTAL SPRINGS	07/02	49.1 ± 142[b]	0.25
BLUE JAY NV			
HOT CREEK RANCH SPRING	03/09	6.5 ± 2.5[b]	0.03
MAINTENANCE STATION	03/09	-1.8 ± 3.1[b]	<0.01
WELL BIAS	03/09	-4.3 ± 2.9[b]	<0.01
WELL HTH-1	03/23	0.88 ± 4.5[b]	<0.01
WELL HTH-2	03/23	2.3 ± 3.0[b]	0.01
WELL SIX MILE	03/09	1.2 ± 3.8[b]	<0.01
FRENCHMAN STATION NV			
HUNT'S STATION	02/26	-2.7 ± 2.8[b]	<0.01
SMITH/JAMES SPRGS	02/26	70 ± 3.7	0.35
WELL FLOWING	02/26	-4.4 ± 2.6[b]	<0.01
WELL H-3	02/26	[c]	
WELL HS-1	02/26	-1.3 ± 3.4[b]	<0.01
AMARGOSA VALLEY NV			
WELL MARY NICKELL'S	02/08	1.4 ± 3.0[b]	<0.01
	08/07	-39 ± 140[b]	<0.01
SHOSHONE CA			
SHOSHONE SPRING	01/02	1.1 ± 3.2[b]	<0.01
	02/06	-2.0 ± 3.6[b]	<0.01
	08/07	-67 ± 140[b]	<0.01
ADAVEN NV			
ADAVEN SPRING	01/09	43 ± 3.4	0.22
	07/02	-40 ± 140[b]	<0.01
ALAMO NV			
WELL 4 CITY	01/11	-2.3 ± 3.2[b]	<0.01
	07/02	-110 ± 140[b]	<0.01
ASH MEADOWS NV	05/09	-0.19 ± 2.8[b]	<0.01
	11/21	310 ± 140[b]	1.59
FAIRBANKS SPRINGS	05/09	-0.96 ± 3.5[b]	<0.01
	11/21	160 ± 140[b]	0.84
SPRING 17S-50E-14CAC	05/09	[d]	
	12/12	-36 ± 140[b]	<0.01
WELL 18S-51E-7DB	05/09	4.9 ± 2.8[b]	0.02
	11/21	32 ± 140[b]	0.16
	05/09	87 ± 5.0	0.43
BEATTY NV			
LOW LEVEL WASTE SITE	06/14	0.99 ± 3.7[b]	<0.01
	12/05	-260 ± 14[b]	<0.01

(continued)

TABLE A8. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S.D. pCi/L (10^{-9} µCi/mL)[a]	% OF CONC. GUIDE
BEATTY NV (con't)			
SPECIE SPRINGS	02/07	170 ± 14[b]	0.87
	07/10	20 ± 2.9	0.10
TOLICHA PEAK	02/07	81 ± 130[b]	0.40
	08/01	0.12 ± 3.8[b]	<0.01
WELL 11S-48-1DD COFFERS	01/04	2.2 ± 2.7[b]	0.01
	07/11	4.8 ± 2.0[b]	0.02
WELL 12S-47E-7DBD CITY	02/09	-58 ± 130[b]	<0.01
	07/12	4.2 ± 2.9[b]	0.02
WELL ROAD D SPICERS	01/08	[d]	
	02/08	210[d] ± 140[b]	1.06
	08/08	-0.89 ± 3.0[b]	<0.01
YOUNGHANS RCH (HOUSE WELL)	06/13	0.42 ± 3.2[b]	<0.01
	12/05	-0.37 ± 2.5[b]	<0.01
BOULDER CITY NV			
LAKE MEAD INTAKE	03/13	-150 ± 130[b]	<0.01
	09/14	44 ± 3.7	0.22
CLARK STATION NV			
WELL 6 TTR	02/07	-35 ± 130[b]	<0.01
	08/09	-2.0 ± 2.6[b]	<0.01
FURNACE CREEK CA	04/24	[d]	
NAVARES SPRINGS			
HIKO NV			
CRYSTAL SPRINGS	01/11	-9.1 ± 140[b]	<0.01
	07/02	49 ± 140[b]	0.24
INDIAN SPRINGS NV			
TROUGH SPRGS-TOIYABE	06/01	28 ± 2.9	0.14
WELL 1 SEWER COMPANY	03/05	81 ± 130[b]	0.40
	05/01	36 ± 140[b]	0.18
	09/04	-1.1 ± 3.0[b]	<0.01
WELL 2 US AIR FORCE	03/05	31 ± 130[b]	0.15
	05/01	260 ± 140[b]	1.30
	09/04	-2.2 ± 2.4[b]	<0.01
LAS VEGAS NV			
WELL 28 WATER DISTRICT	03/14	96 ± 140[b]	0.48
	09/14	-2.1 ± 4.4[b]	<0.01
LATHROP WELLS NV			
CITY 15S-50E-18CDC	04/03	1.5 ± 3.5[b]	<0.01
NYALA NV			
SHARP'S RANCH	02/06	69 ± 130[b]	0.35
	08/08	-2.3 ± 4.0[b]	<0.01
OASIS VALLEY NV			
GOSS SPRINGS	02/08	-58 ± 130[b]	0.29
	08/14	-4.2 ± 3.0[b]	<0.01
PAHRUMP NV			
CALVADA WELL	02/06	-1.2 ± 2.8[b]	<0.01
	08/10	-110 ± 140[b]	<0.01
	09/04	-120 ± 140[b]	<0.01

(continued)

TABLE A8. Continued

SAMPLING LOCATION	COLLECTION DATE 1990	CONC. ± 1 S.D. pCi/L (10^{-9} μCi/mL)[a]	% OF CONC. GUIDE
RACHEL NV	04/11	-73.8 ± 136[b]	<0.01
WELLS 7 AND 8	10/01	0.6 ± 3.2[b]	<0.01
PENOYER	10/01	0.58 ± 3.2[b]	<0.01
	04/11	-74 ± 130[b]	<0.01
WELL 13 PENOYER	10/01	6.3 ± 3.4[b]	0.03
	04/11	180 ± 130[b]	0.91
WELL PENOYER CULINARY	10/01	-3.6 ± 3.9[b]	<0.01
	04/04	310 ± 130[b]	1.57
TEMPIUTE NV			
UNION CARBIDE WELL	2/07	-58 ± 130[b]	<0.01
	08/08	-0.65 ± 3.1[b]	<0.01
TONOPAH NV			
CITY WELL	03/07	-19 ± 130[b]	<0.01
	09/06	-2.6 ± 2.8[b]	<0.01
WARM SPRINGS NV			
TWIN SPRINGS RANCH	09/05	-51 ± 140[b]	0.25
	04/03	100 ± 130[b]	0.52
	11/12	3.2 ± 3.0[b]	0.02
NEVADA TEST SITE (AREA) NV			
WELL 6A ARMY	01/11	150 ± 140[b]	0.79
	07/19	3.3 ± 3.5[b]	0.02
WELL C-1	04/16	0.78 ± 2.9[b]	<0.01
	11/20	-260 ± 140[b]	<0.01
WELL D TEST	01/03	5.1 ± 3.3[b]	0.03
	07/19	-8.9 ± 140[b]	<0.01
WELL HTH-1	06/07	39 ± 3.6	0.19
WELL UE1C	01/04	0.0 ± 3.2[b]	0.00
	07/19	-1.6 ± 1.9[b]	<0.01
WELL UE5C	03/05	4.4 ± 3.2[b]	0.02
	09/10	-0.55 ± 4.6[b]	<0.01
WELL UE-5N	12/07	70 ± 4.6	0.35
WELL UE6E	03/06	33 ± 2.7	0.17
WELL UE15D	04/16	8.4 ± 2.5	0.04
	11/20	270 ± 140[b]	1.36
WELL UE16D	05/15	-0.27 ± 2.7[b]	<0.01
	11/19	0.0 ± 140[b]	0.00
WELL UE-16F	05/14	9.2 ± 3.0[b]	0.05
	11/19	250 ± 140[b]	1.30
WELL UE-17A	05/14	2.9 ± 2.6[b]	0.01
	12/11	-140 ± 140[b]	<0.01
WELL UE18R	06/06	1.5 ± 2[b]	<0.01
	12/11	-140 ± 140[b]	<0.01
WELL UE-18T	06/06	210 ± 3.5	1.05

[a] *Multiply by 3.7 x 10^{-2} to convert to Bq/L.*

[b] *Concentration is less than the minimum detectable concentration (MDC).*

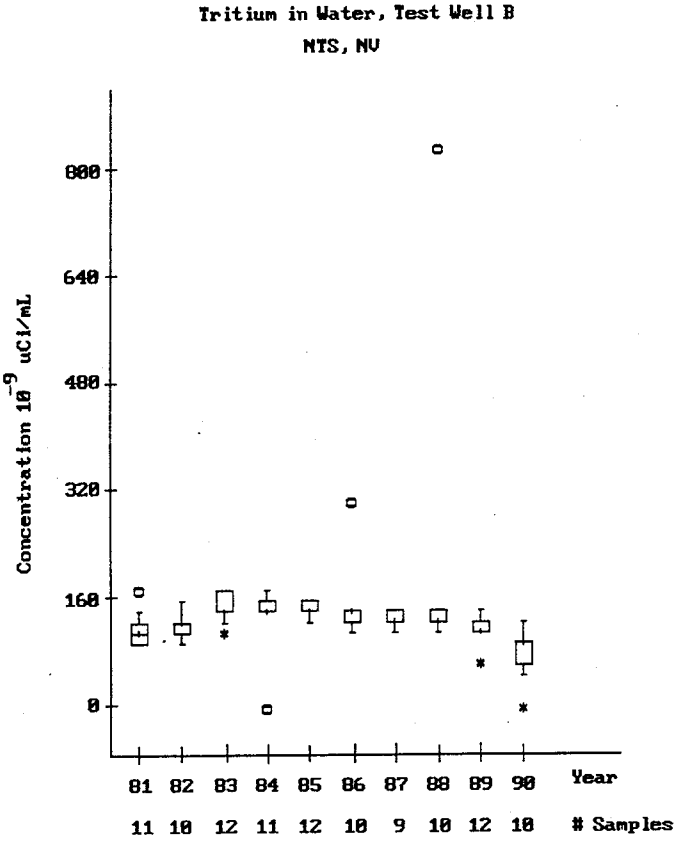
[c] *No sample.*

[d] *Gamma spectra negligible.*

(continued)

TABLE A8. Continued

	ANALYSIS	RESULT ± 1 S.D. (pCi/L)	(10^{-9}μCi/mL) = pCi/L
(1)	^{137}Cs	180	7.9
(2)	^{137}Cs	64	6.7
(3)	^{3}H(avg.)	28,000,000	100,000
	^{40}K	7,600	1,500
	^{89}Sr	790,000	30,000
	^{90}Sr	-19	48
	^{238}Pu	0.054	0.07
	$^{239+240}$Pu	1.1	0.17
(4)	^{137}Cs	13	3.8



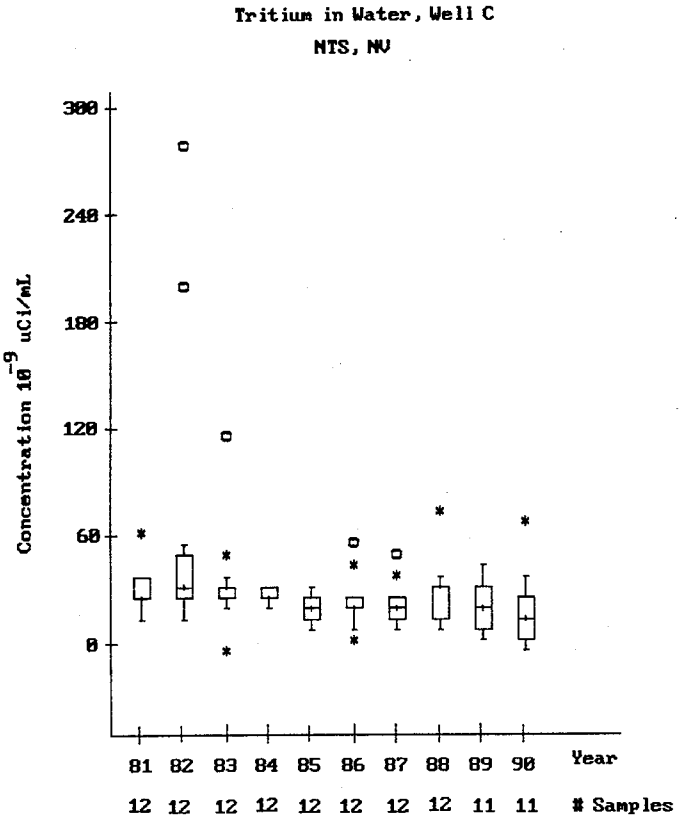
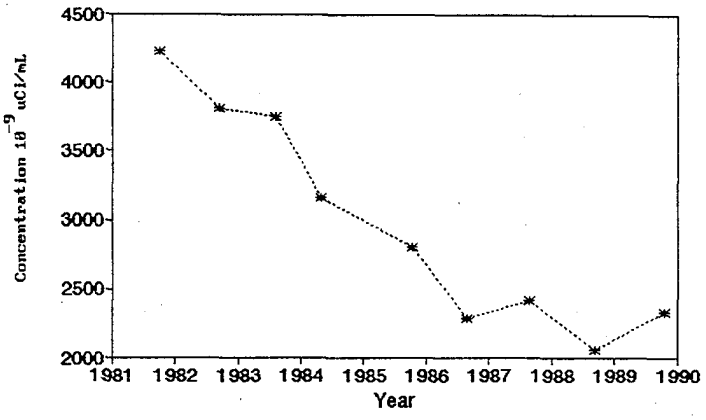
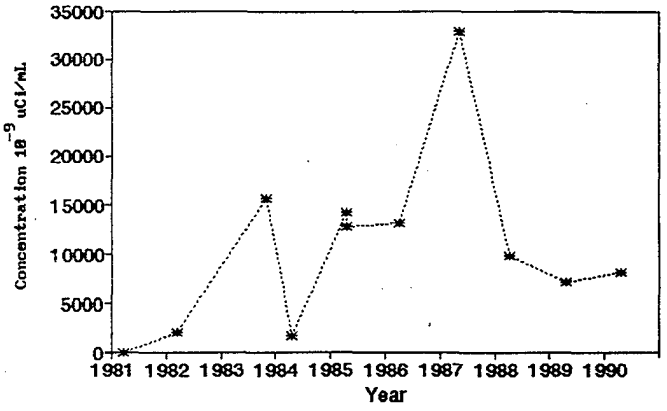


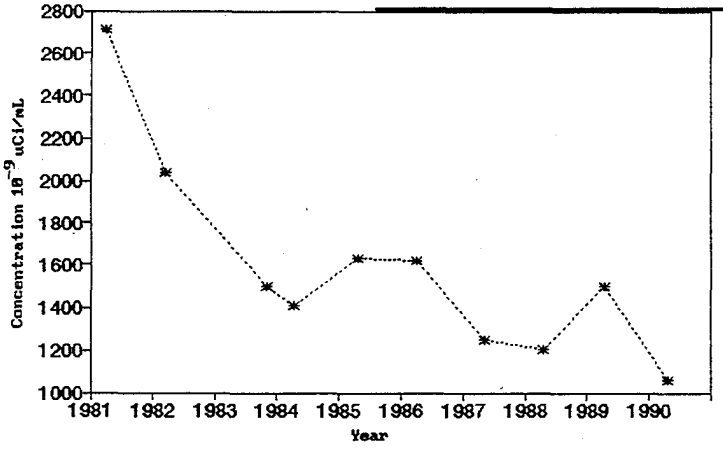
Figure A31. Historical trends of ^{3}H in water samples by location.



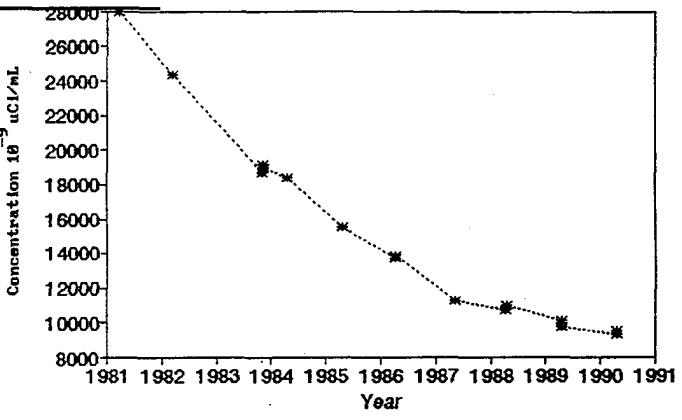
Well GZ-1 Longshot, AZ



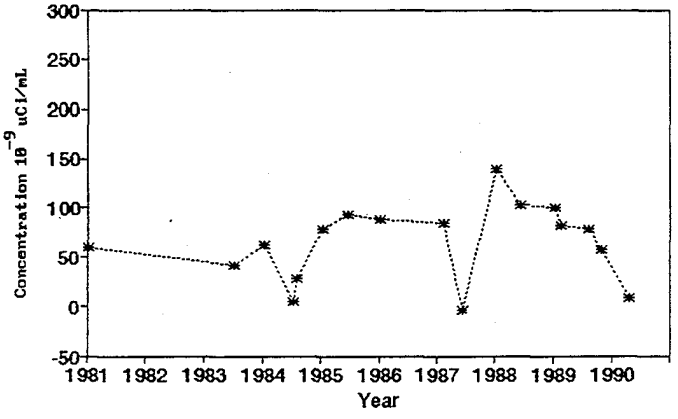
Well HMH-2 Dribble, MS



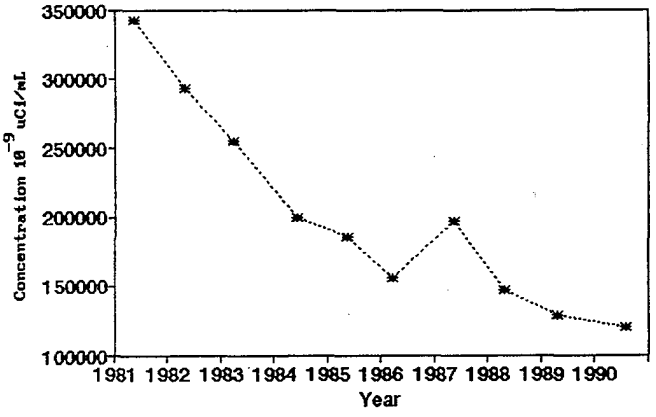
Well HM-L2 Dribble, MS



Well HM-S Dribble, MS

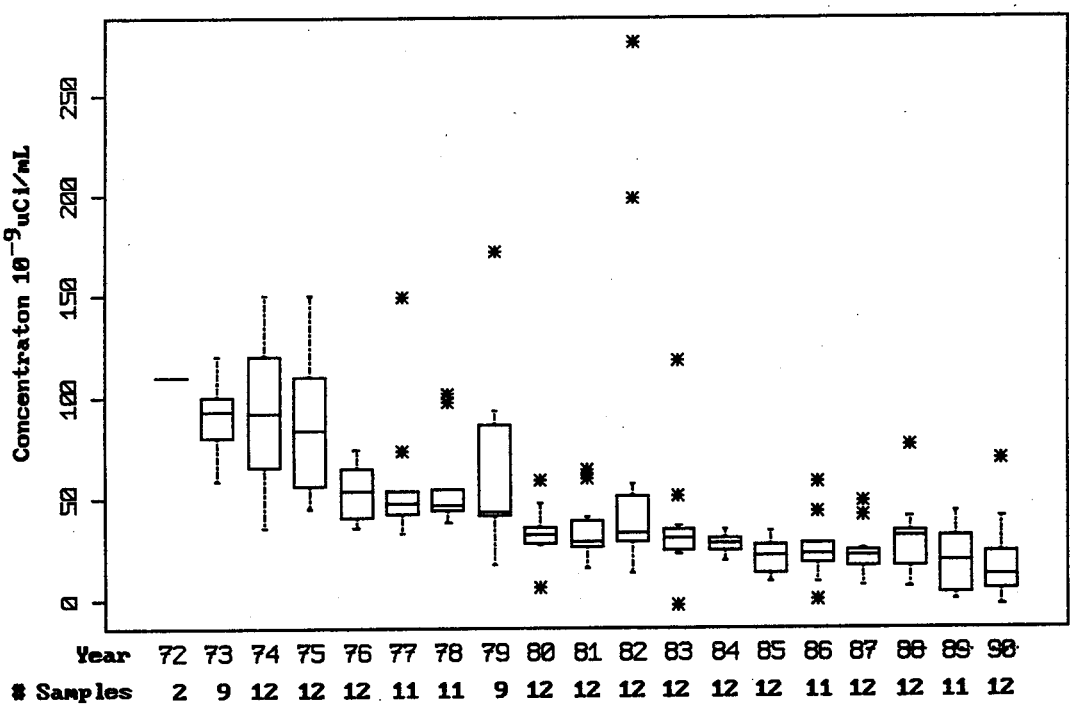


Well UE15D NTS, NV

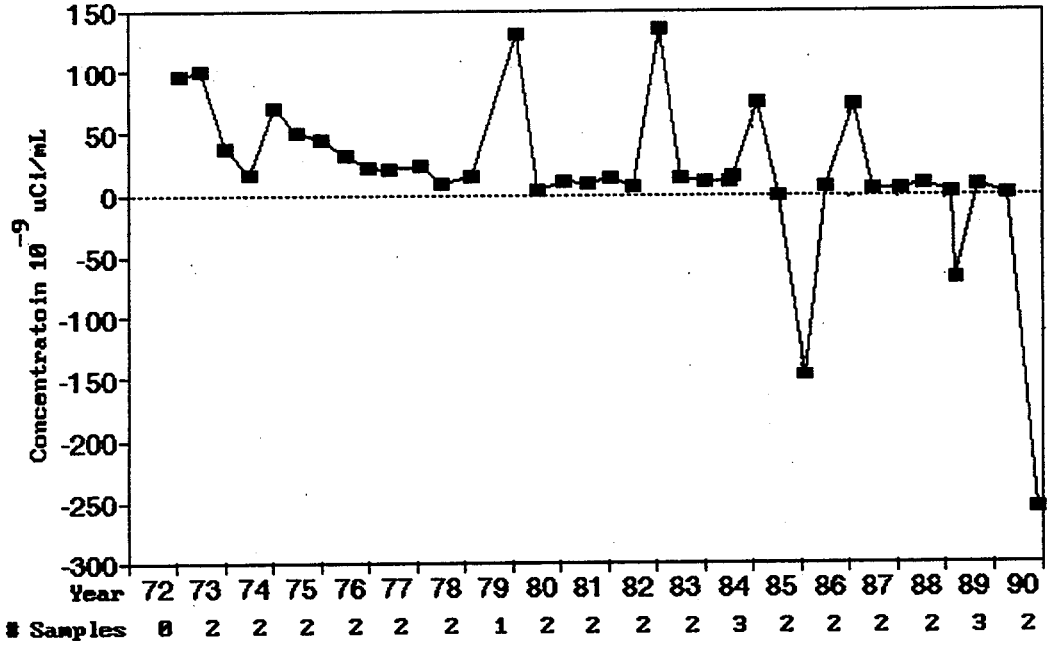


Well USGS-8 Gnome, NM

Figure A32. Water data plots.



Well C, NTS, NV



Well C1, NTS, NV

Figure A32. Continued.

TABLE A9. EPA QUALITY ASSURANCE INTERCOMPARISON RESULTS — 1990

NUCLIDE	MONTH	KNOWN VALUE (10^{-9}µCi/mL)[a]	GRAND AVG. (10^{-9}µCi/mL)[a]	LAB AVG. (10^{-9}µCi/mL)[a]	NORMALIZED DEVIATION FROM KNOWN CONCENTRATION
Water Intercomparison Studies:					
Alpha	Jan	12.0	11.5	8.3	1.3
Alpha	Apr	90.0	81.2	ND	NA
Alpha	May	22.0	17.0	ND	NA
Alpha	Sep	10.0	10.0	ND	NA
Alpha	Oct	62.0	60.6	ND	NA
Beta	Jan	12.0	12.9	13.3	0.5
Beta	Apr	52.0	49.1	ND	NA
Beta	May	15.9	16.2	ND	NA
Beta	Sep	10.0	10.9	ND	NA
Beta	Oct	53.0	50.8	ND	ND
^{3}H	Feb	4976.0	4915.6	5531.0	1.9
^{3}H	Jun	2933.0	2066.8	3230.0	1.4
^{3}H	Oct	7203.0	7125.1	7281.3	0.2
^{60}Co	Feb	15.0	15.3	15.3	0.1
^{60}Co	Jun	24.0	25.1	25.7	0.6
^{60}Co	Oct	20.0	20.5	20.0	0.0
^{65}Zn	Feb	139.0	138.9	136.3	0.3
^{65}Zn	Jun	148.0	149.2	157.3	1.1
^{65}Zn	Oct	115.0	116.2	112.3	0.4
^{89}Sr	Jan	25.0	25.3	22.3	0.9
^{89}Sr	Apr	10.0	9.6	10.7	0.2
^{89}Sr	May	7.0	7.6	7.3	0.1
^{89}Sr	Sep	10.0	9.9	8.3	0.6
^{89}Sr	Oct	20.0	18.8	17.3	0.9
^{90}Sr	Jan	20.0	19.2	17.0	3.5[b]
^{90}Sr	Apr	10.0	9.5	8.0	2.3
^{90}Sr	May	7.0	7.0	6.3	0.2
^{90}Sr	Sep	9.0	9.3	9.3	0.1
^{90}Sr	Oct	15.0	14.4	12.3	0.9
^{106}Ru	Feb	139.0	133.6	128.3	1.3
^{106}Ru	Jun	210.0	201.0	193.0	1.4
^{106}Ru	Oct	151.0	140.4	131.3	2.3
^{131}I	Aug	39.0	40.3	44.3	1.5
^{133}Ba	Feb	74.0	72.5	76.7	0.7
^{133}Ba	Jun	99.0	96.3	100.0	0.2
^{133}Ba	Oct	110.0	107.7	105.7	0.7
^{134}Cs	Feb	18.0	17.0	17.0	0.3
^{134}Cs	Apr	15.0	14.4	13.0	0.7
^{134}Cs	Jun	24.0	23.3	22.3	0.6
^{134}Cs	Oct	12.0	11.9	10.7	0.5
^{134}Cs	Oct	7.0	7.5	7.0	0.0
^{137}Cs	Feb	18.0	18.8	19.0	0.3
^{137}Cs	Apr	15.0	15.8	15.0	0.0

(continued)

TABLE A9. Continued

NUCLIDE	MONTH	KNOWN VALUE (10^{-9}µCi/mL)[a]	GRAND AVG. (10^{-9}µCi/mL)[a]	LAB AVG. (10^{-9}µCi/mL)[a]	NORMALIZED DEVIATION FROM KNOWN CONCENTRATION
^{137}Cs	Jun	25.0	26.2	26.0	0.3
^{137}Cs	Oct	12.0	13.1	12.0	0.0
^{137}Cs	Oct	5.0	5.9	5.0	0.0
^{226}Ra	Mar	4.9	5.2	5.7	2.0
^{226}Ra	Apr	5.0	5.0	ND	NA
^{226}Ra	Jul	12.1	11.4	ND	NA
^{226}Ra	Oct	13.6	12.7	ND	NA
^{226}Ra	Nov	7.4	7.1	ND	NA
^{228}Ra	Mar	12.7	12.2	14.7	1.9
^{228}Ra	Apr	10.2	10.4	ND	NA
^{228}Ra	Jul	5.1	5.5	ND	NA
^{228}Ra	Oct	5.0	5.4	ND	NA
^{228}Ra	Nov	7.7	8.1	ND	NA
U(Nat.)	Mar	4.0	4.2	4.0	0.0
U(Nat.)	Apr	20.0	19.2	20.0	0.0
U(Nat.)	Jul	20.8	19.2	20.9	0.1
U(Nat.)	Oct	10.2	10.1	10.3	0.1
U(Nat.)	Nov	35.5	34.3	33.5	1.0
$^{239+240}$Pu	Jan	5.6	5.2	4.8	2.4
$^{239+240}$Pu	Aug	9.1	8.3	8.9	0.4
Milk Intercomparison Studies:					
^{89}Sr	Apr	23.0	23.1	18.7	1.5
^{89}Sr	Sep	16.0	13.5	12.7	1.2
^{90}Sr	Apr	23.0	22.3	19.7	1.2
^{90}Sr	Sep	20.0	17.6	18.0	0.7
^{131}I	Apr	99.0	98.0	98.0	0.2
^{131}I	Sep	58.0	58.9	63.3	1.5
^{137}Cs	Apr	24.0	24.7	25.3	0.5
^{137}Cs	Sep	20.0	21.5	20.3	0.1
Air Filter Intercomparison Studies:					
Alpha	Mar	5.0	6.3	6.0	0.3
Alpha	Aug	10.0	12.2	14.0	1.4
Beta	Mar	31.0	32.2	36.7	2.0
Beta	Aug	62.0	64.7	80.3	6.4[b]
^{90}Sr	Mar	10.0	9.7	11.0	1.2
^{90}Sr	Aug	20.0	19.4	18.7	0.5
^{137}Cs	Mar	10.0	11.6	10.7	0.2
^{137}Cs	Aug	20.0	22.7	22.3	0.8

ND = Analytical results were not received.
NA = Not applicable.
[a] = *Multiply by 3.7 x 10^7 to obtain Bq/L.*
[b] = *Analytical results outside of control limits.*

TABLE A10. QUALITY ASSURANCE RESULTS FOR THE BIOMONITORING PROGRAM — 1990

SAMPLE ID AND SHIPMENT NUMBER	NUCLIDE	ACTIVITY ADDED pCi/g ASH	ACTIVITY REPORTED pCi/g ASH
Spiked Samples:			
Ash-1	$^{239+240}Pu$	0.34	Lost in Chemistry
82	^{90}Sr	2.19	0.9 ± 0.004
Ash-2	$^{239+240}Pu$	0.37	Lost in Chemistry
82	^{90}Sr	2.4	1.6 ± 0.07
Ash-3	$^{239+240}Pu$	0	Lost in Chemistry
82	^{90}Sr	0	0.23 ± 0.003
Ash-4	$^{239+240}Pu$	0	Lost in Chemistry
82	^{90}Sr	0	0.2 ± 0.002
Ash-1	$^{239+240}Pu$	0.35	0.32 ± 0.015
84	^{90}Sr	0	Lost in Chemistry
Ash-2	$^{239+240}Pu$	0	0.0002 ± 0.0015
84	^{90}Sr	1.5	Lost in Chemistry
Ash-3	$^{239+240}Pu$	0	0.002 ± 0.003
84	^{90}Sr	0	Lost in Chemistry
Ash-1	$^{239+240}Pu$	0	0.0007 ± 0.0019
86	^{90}Sr	1.65	Lost in Chemistry
Ash-2	$^{239+240}Pu$	0	Lost in Chemistry
86	^{90}Sr	2.05	Lost in Chemistry
Ash-3	$^{239+240}Pu$	0.448	0.47 ± 0.08
86	^{90}Sr	0	Lost in Chemistry
Ash-4	$^{239+240}Pu$	0.468	Lost in Chemistry
86	^{90}Sr	0	Lost in Chemistry
Ash-5	$^{239+240}Pu$	0	Lost in Chemistry
86	^{90}Sr	0	Lost in Chemistry
Ash-6	$^{239+240}Pu$	0	Lost in Chemistry
86	^{90}Sr	0	Lost in Chemistry
Special Shipment:			
Ash-1	^{90}Sr	1.85	1.22
Ash-2	^{90}Sr	1.95	1.37
Ash-3	^{90}Sr	2.01	2.00
Ash-4	^{90}Sr	1.98	1.94
Duplicate Samples:			
Bone Cow #1	$^{239+240}Pu$	0	0.0008 ± 0.005
84	^{90}Sr	0	1.1 ± 0.03

(continued)

TABLE A10. Continued

SAMPLE ID AND SHIPMENT NUMBER	NUCLIDE	ACTIVITY ADDED pCi/g ASH	ACTIVITY REPORTED pCi/g ASH
Dup Bone Cow #1	$^{239+240}Pu$	0	0.0006 ± 0.0005
84	^{90}Sr	0	1.2 ± 0.01
Dup Liver Cow #1	$^{239+240}Pu$	0	0.009 ± 0.002
84			
Dup Liver Cow #1	$^{239+240}Pu$	0	0.02 ± 0.003
87			
Bone Cow #5	$^{239+240}Pu$	0	-0.0003 ± 0.0004
86	^{90}Sr	0	0.8 ± 0.02
Dup Bone Cow #5	$^{239+240}Pu$	0	0.001 ± 0.0007
86	^{90}Sr	0	0.7 ± 0.02
Liver Cow #5	$^{239+240}Pu$	0	0.03 ± 0.003
86			
Dup Liver Cow #5	$^{239+240}Pu$	0	0.02 ± 0.003
86			
Liver Cow #6	$^{239+240}Pu$	0	0.004 ± 0.001
86			
Dup Liver Cow #6	$^{239+240}Pu$	0	0.004 ± 0.001
86			

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